



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: August 2018

Module Number: ME 3302

Module Name: Metallurgy for Engineers

[Three Hours]

[Answer all questions, each question carries 12 marks]

-
- Q1. a) Blast furnace is used to produce pig iron from iron ores.
- i) Sketch a diagram of blast furnace which is used to produce pig iron and name main parts. [2.0 Marks]
- ii) What are the indirect reduction and direct reduction reactions which can be taken place inside the blast furnace during pig iron production? [2.0 Marks]
- b) Pig iron cannot be used as it is due to the lack of mechanical properties and need to be converted into steel using different techniques.
- i) State the advantages and disadvantages of steel making in the electric arc furnace. [2.0 Marks]
- ii) What are the roles of slag in steel making process? [2.0 Marks]
- c) Compare the microstructure, properties and applications of gray cast iron and ductile cast iron. [3.0 Marks]
- d) Calculate the Carbon Equivalent (C.E.) value for the cast iron with a composition of 3.0 wt% of C, 2.8 wt% of Si and 1.1 wt% of P. [1.0 Mark]
- Q2. a) Briefly discuss on the statement "Indirect cost associated with corrosion is higher than the direct cost associated with corrosion". [2.0 Marks]
- b) i) Describe how does a pressure vessel made using austenitic stainless steel (304SS) sheets following multi-pass welding, corrode (closed to the weld) when exposed to corrosive media? [3.0 Marks]
- ii) Suggest a more suitable type of steel sheets that can be used to fabricate the vessel to protect from the above mentioned corrosion type and explain the reasons for your suggestion. [3.0 Marks]

c) Identify the most probable corrosion type in following circumstances and suggest the preventive measures to control the corrosion. Use neat sketches if necessary.

i) Large copper plates fixed with steel bolt and nut (Figure 01).

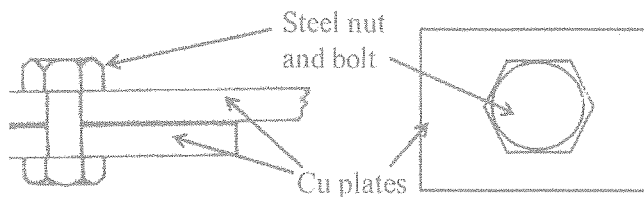


Figure 01

[2.0 Marks]

ii) Water droplet on steel plate (Figure 02)

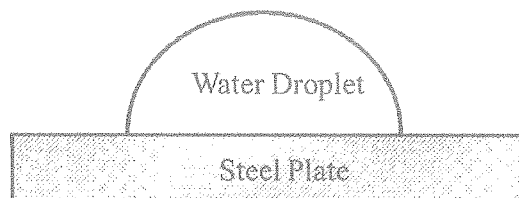


Figure 02

[2.0 Marks]

Q3. a) Mechanical properties of steel can be altered by heat treatments without changing the composition.

i) State four different heat treatment processes that are used to alter the bulk properties of steel.

[1.0 Mark]

ii) "Rate of heating to the required temperature" is one of the major factor to be considered before starting heat treatment of plain carbon steel parts. Explain.

[2.0 Marks]

b) Differentiate the phase transformation occur during hardening (quenching) and full annealing processes of medium carbon steel.

[3.0 Marks]

c) Describe the following surface hardening processes with neat sketches.

- i) Carburizing
- ii) Nitriding
- iii) Induction hardening

[6.0 Marks]

- Q4. a) Failure of metallic materials can be mainly divided into two types as ductile failure and brittle failure. Explain, why BCC metals do fail due to brittle fracture at low temperature while FCC metals do not. [3.0 Marks]
- b) Describe briefly the experimental procedure to measure fracture toughness of metallic materials. [3.0 Marks]
- c) Figure 03 shows the Fe-Fe₃C equilibrium phase diagram.
- i) Label the missing phase regions (Named as A, B, C, and D), upper critical temperature (A₃), lower critical temperature (A₁) and Eutectoid point in the given diagram (Figure 03) and attach page 4 to the answer script. [2.0 Marks]
- ii) Why martensite and bainite phases are not present in Fe-Fe₃C equilibrium diagram.? [1.0 Mark]
- d) For an iron-carbon alloy of composition 1.5 wt% of C, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at 1100 °C, 800 °C and 600 °C. Label all the phases. [3.0 Marks]
- Q5. a) Gibbs' phase rule can be written as $F = C - P + 2$ for system with both pressure and temperature change.
- i) Describe the Gibbs' phase rule and define the F, C and P in the above equation. [2.0 Marks]
- ii) State the application of Gibbs' phase rule. [2.0 Marks]
- iii) Can four phases exist together in unary phase system? Explain your answer. [2.0 Marks]
- b) Non-ferrous alloys are extensively used in various applications due to their excellent physical and mechanical properties. Describe briefly the properties and applications of the following alloys;
- i) Nichrome
- ii) Duralumin
- iii) Nitinol [6.0 Marks]

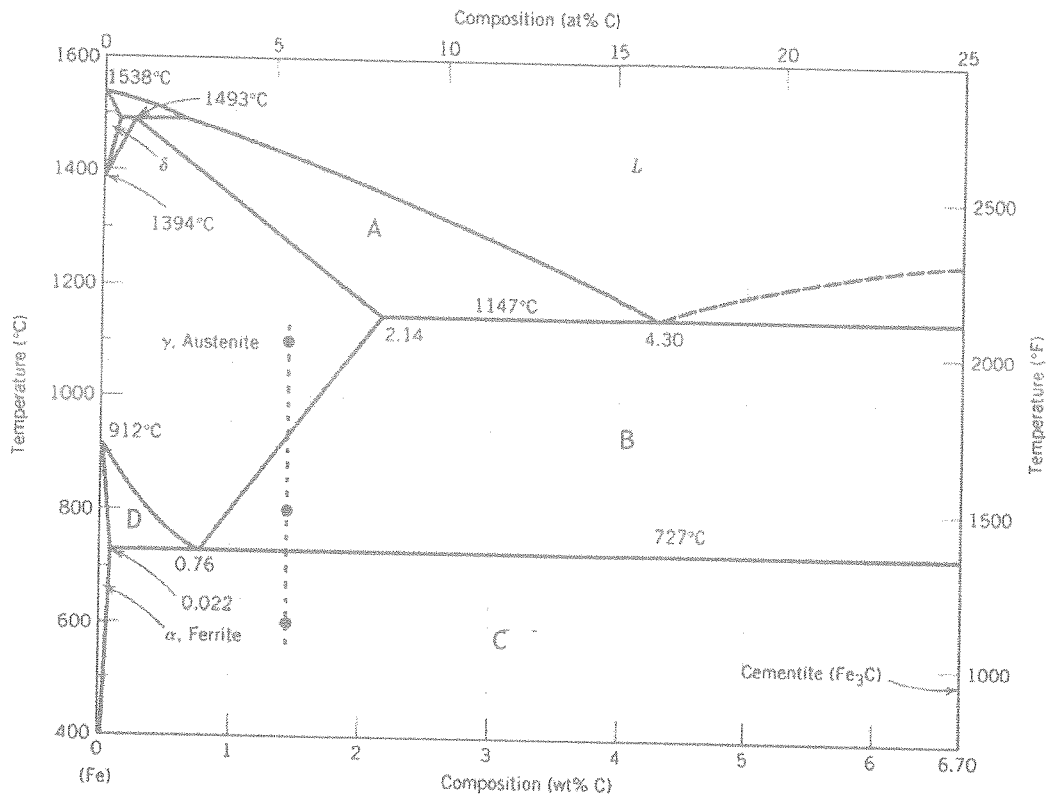


Figure 03