



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2021

Module Number: ME 3304

Module Name: Metallurgy for Engineers (C-18)

[Three Hours]

[Answer all questions, each question carries 12 marks]

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- Q1. Properties of engineering materials should be tested to identify the suitability for any particular engineering application.
- a) Differentiate between *destructive* and *non-destructive* tests of engineering materials. [2.0 Marks]
 - b)
 - i) Describe briefly the Brinell hardness testing method to measure the hardness value of medium carbon steel gear wheel. Explain the calculation procedure. Define all the parameters used in calculation. [4.0 Marks]
 - ii) How does the Rockwell hardness test differ from other hardness testing methods? [2.0 Marks]
 - c) Explain, why do dislocations in FCC (Faced Centered Cubic) materials stay mobile at low temperatures while dislocations in BCC (Body centered Cubic) materials find it increasingly difficult to move as the temperature is lowered? [4.0 Marks]
- Q2. By considering the excellence properties, steel to be the most important engineering material. Around 2500 different grades are produced to cater the need of several industries ranging from structural to aero-space.
- a)
 - i) Iron ores are used as raw materials in pig iron production. Describe briefly the main three types of iron ores; *hematite*, *magnetite* and *siderite*. [3.0 Marks]
 - ii) Reduction of iron ores in the blast furnace followed by the *direct reduction* and *indirect reduction* during production of pig iron. Give examples for the reduction reaction in both cases. [1.0 Mark]
 - b) Steel can be produced by using *Bessemer process* and *open hearth process*. Discuss briefly the advantages of *open hearth process* over *Bessemer process*. [2.0 Marks]

c) Alloying elements are added during steel production to enhance the properties of steel. Describe the effect of following alloying elements in steel.

- i) Manganese (Mn)
- ii) Nickel (Ni)
- iii) Chromium (Cr)
- iv) Sulfur (S)

[6.0 Marks]

Q3. Mechanical properties of the steel components with same composition will be differ according to their microstructure. Microstructure of steel can be changed by different heat treatments.

a) Define the terms *heat treatment* and *recrystallization temperature*.

[2.0 Marks]

b) What are the purposes of the heat treatments?

[2.0 Marks]

c) Discuss the differences between *full annealing* and *spheroidizing annealing* treatments of steel. Processing conditions (temperature, cooling rate), purposes and resulting microstructures should be considered. Use neat sketches.

[4.0 Marks]

d) Write short notes on following heat treatment processes.

- i) Carburizing of low carbon steel gear wheel.
- ii) Induction hardening of medium carbon steel tube.

[4.0 Marks]

Q4. a) Gibbs' phase rule describes the possible number of degrees of freedom in a (closed) system at equilibrium, in terms of the number of components and the number of separate phases in the system. Mathematically it can be presented for the one component system as, $F = C - P + 2$.

Calculate the degree of freedom, F in the following situations. (See Figure Q4, a)

- i) Within each phase region
- ii) Along a phase boundary
- iii) At the triple point

[4.0 Marks]

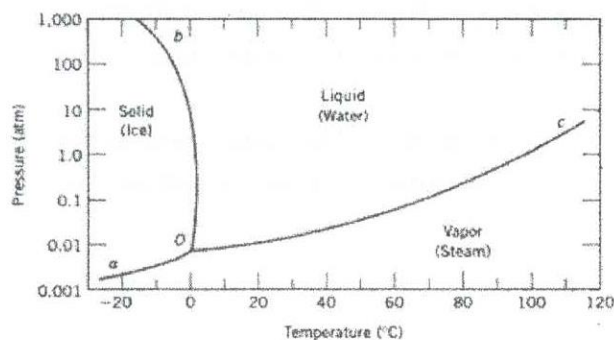


Figure Q4, a

- b) TTT diagram is useful in giving an overall picture of the transformation behavior of austenite during cooling at different rates.

Describe the phase transformation in 0.76% C carbon steel which is cooling along the path 1, 2, 3 and 4 as shown in the Figure Q4,b.

[4.0 Marks]

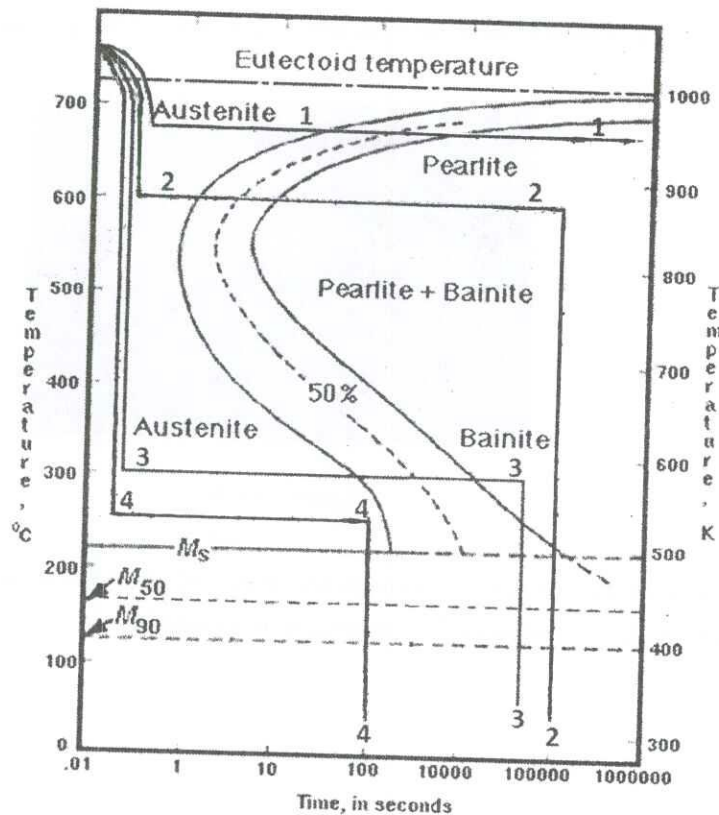


Figure Q4, b

- c) Explain briefly the differences between the ferrite, perlite, bainite and martensite phases referring to the crystal structure, microstructure and mechanical properties. Use neat sketches.

[4.0 Marks]

- Q5. a) Corrosion leads to failure of most of the metal structures. Some of the corrosion types can be observed and others cannot be detected till the failure of the structure occurs.

i) Discuss briefly on the *indirect cost* associated with corrosion.

[2.0 Marks]

ii) What are the requirements for the formation of an electrochemical cell?

[1.0 Mark]

iii) Explain the cathodic and anodic reactions occur in the electrochemical cell formed when corrosion of steel parts.

[2.0 Marks]

- b) i) Iron corrodes faster than aluminium, even though iron is placed below aluminium in the electrochemical series. Explain. [1.0 Mark]
- ii) Photograph of the surface of the "I" shaped steel beam which has been used to construct roof of a swimming pool is shown in Figure Q5,b. There are micro and macro holes on the surface due to the corrosion. Identify the type of corrosion and discuss the reactions at the anodic and cathodic areas. [3.0 Marks]



Figure Q5, b

- c) Discuss the corrosion prevention methods based on *materials selection* and *proper design*. Use neat sketches as much as possible. [3.0 Marks]