University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours
Level 2 (Semester 1) Examination, March 2021

Course Unit: ENT 2152- Properties of Material and Their Applications Duration: 2 hours

Instructions to Candidates

- Answer all (04) questions.
- All symbols have their usual meaning.
  - Electron charge, $e = 1.602 \times 10^{-19}$ C
- All the figures are attached in separate document.

1. Suppose you are working at Beverage Company. You are asked to develop a container to store carbonate beverage.

I.

a) What are the different material types that you are suggested to use for producing those containers?

(03 marks)

b) Indicate three requirements or properties of materials that you are considering when selecting the above material.

(03 marks)

II.

a) Define the following terms:
   i. Coordination Number (CN)
   ii. Atomic Packing Factor (APF)

(04 marks)

b) Sketch crystal structures of Face Centered Cubic (FCC) and Body Centered Cubic (BCC) crystal.

(04 marks)

c) Calculate the volume of an FCC unit cell in terms of the atomic radius R.

(04 marks)

d) Using above equation in part II (c) calculate the Atomic Packing Factor (APF) for the crystal structure. (Use π=3.14)

(07 marks)

2. Universal Tensile Testing Machine (UTM) is used to obtain stress-strain graph. The graph in figure 1 is a tensile stress-strain curve obtained for a brass specimen.

I.

a) Identify the point A, B and C on the attached graph in figure 1.

(03marks)

Using the same graph determine;

b) The modulus of elasticity.

(03 marks)

a) The yield strength.

(02 marks)

c) The maximum load that can be sustained by a cylindrical specimen having an original diameter of 3 mm. (Use π=3.14)

(04 marks)

d) Find the change in length (Δl) of a specimen originally 250 mm long that is subjected to a tensile stress of 350 MPa.

(03 marks)

II. Fracture is the separation or fragmentation of a body into two or more pieces in response to an imposed stress. The figure 2 indicates fractures obtained for two different materials.

a) Give the specific names for above (a) and (b) fractures.

(02 marks)

b) Draw the tensile stress-strain behavior for above two fracture materials using stress-strain graph.

(03 marks)

c) Write the process or stages of the fracture indicates in figure 2(a).

(05 marks)

3. An intrinsic semiconductor containing high purity silicon has a carrier concentration (n_i) of $2.0 \times 10^{19}\ m^{-3}$. Then Arsenic atoms with a density of $4.5 \times 10^{23}\ m^{-3}$ are added to it. The mobilities of electrons and holes are 0.4 $m^2/(Vs)$ and 0.2 $m^2/(Vs)$, respectively.

I.

a) Write an equation to find the electrical conductivity of intrinsic semiconductor.

(02 marks)

b) Find the resistivity of the semiconductor before the addition of Arsenic atoms.

(07 marks)

c) What is the conductivity type after the addition of Arsenic to high purity Silicon? (n-type or p-type)

(02 marks)

d) How would you modify the above equation in part I.a for n-type and p-type semiconductor materials?

(04 marks)

e) Calculate the electrical conductivity of material after the addition of Arsenic.

(04 marks)

II. The electrical properties of metal, semiconductor and insulator are a consequence of their band structures. That is arrangement of the outermost electron bands and the way in which they are filled with electrons.

Draw the band structure of each above-mentioned material and briefly explain how electrical properties change due to the band structure.

(06 marks)

4. A portion of the iron-carbon phase diagram is given in figure 3 in the attachment. Carbon is an interstitial impurity in iron. It forms a solid solution with different phases of iron. Answer the questions referring the figure 3.

I.

a) What is the main difference between steel and cast iron?

(02 marks)

b) Write the corresponding crystal structure and maximum solubility of carbon in α-ferrite, γ-austenite and δ-ferrite phases.

(06 marks)

c) Briefly describe Eutectic and Eutectoid reaction in iron-carbon phase diagram.

(07 marks)

II. An iron carbon alloy consisting 0.76wt% of carbon composition is slowly cooled down from a temperature 800°C.

a) Sketch the equilibrium microstructure of the austenite phase at temperature 800°C.

(03 marks)

b) Sketch the equilibrium microstructure of the perlite structure below the temperature of 727°C.

(03 marks)

III. Heat treatment is a process, controlled heating and cooling operations used to bring about a desired change in the properties of the metal. Annealing and quenching are two major heat treatment methods.

a) Compare the annealing and quenching heat treatment methods in terms of the process and expected mechanical properties.

(04 marks)

University of Ruhuna- Faculty of Technology

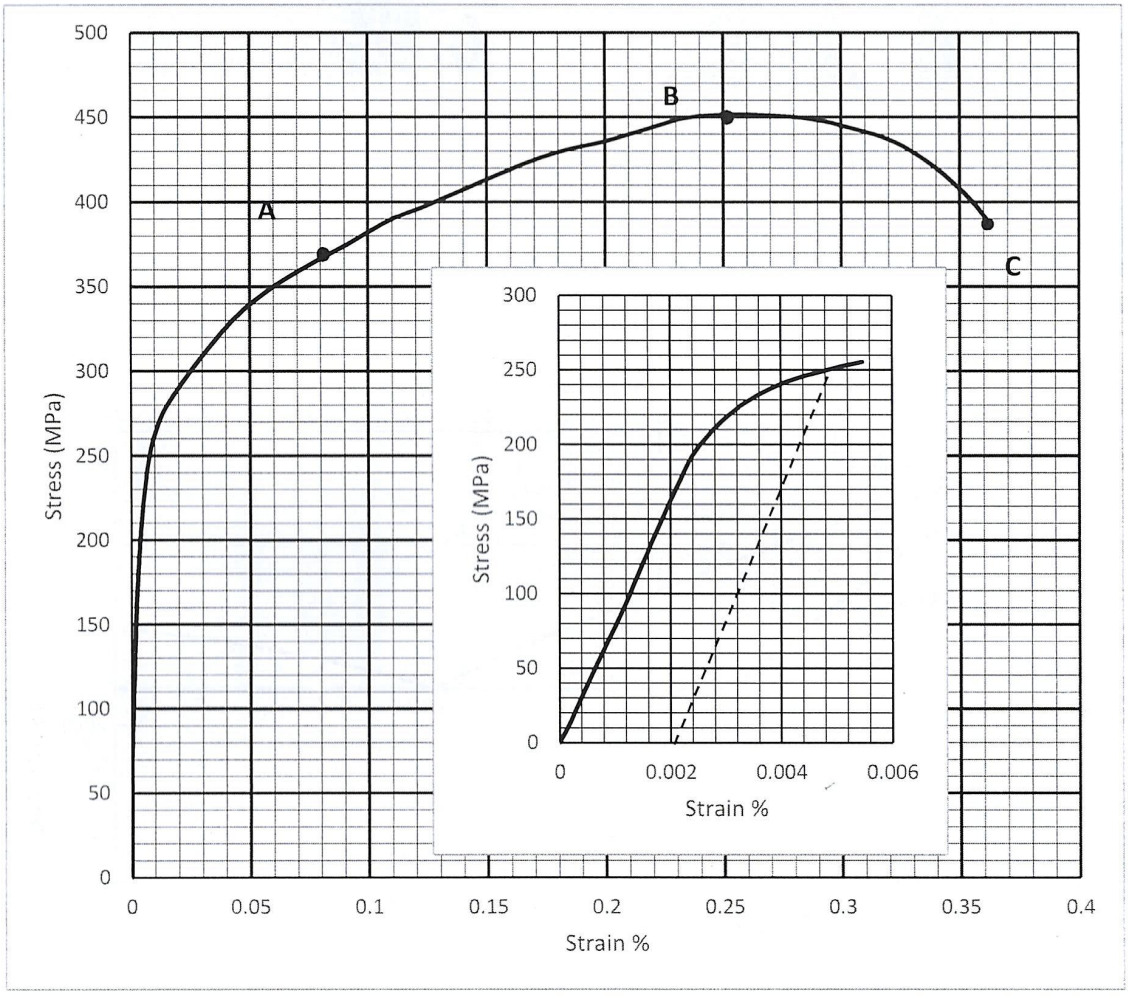
Bachelor of Engineering Technology Honours

Level 2 (Semester 1) Examination, March 2021

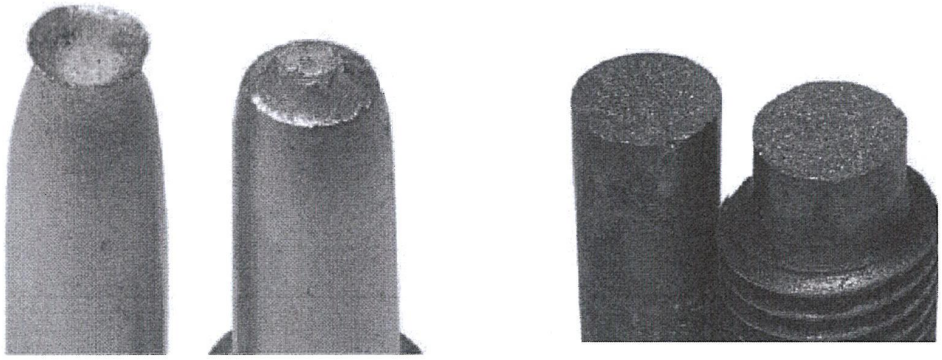
ENT 2152- Properties of Material and Applications

Attachement I- Figures

Question 2- I - Figure 1



Question 2-II- Figure 2



(a) *(b)*

Question 4-I & II- Figure 3