MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY ORDINARY EXAMINATION

2024/2025 ACADEMIC YEAR

SECOND YEAR **FIRST** SEMESTER EXAMINATION FOR BACHELOR OF TECHNOLOGY IN MECAHNICAL ENGINEERING

EMT 204 – MATERIALS SCIENCE

DURATION: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. Answer question ONE and any other two questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

SECTION A – ANSWER ALL QUESTIONS IN THIS SECTION

QUESTION ONE (30 MARKS)

(a) Explain the term annealing and state the reason for conveying out the process. (4 marks)

(b) Explain the following terms as applied in material science.

i. Fatigue life (1 mark)

ii. Fatigue strength (1 mark)

iii. Stress (1 mark)

iv. Strain (1 mark)

v. Elastic strain (1 mark)

vi. Proof stress (1 mark)

(c) A piece of copper originally 305 mm long is pulled in tension with a stress of 276 MPa. If the deformation is entirely elastic, what will be the resultant elongation? Take E=110 GPa. (3 marks)

(d) Explain the reason why only small concentration of carbon atoms is soluble in α-ferrite (bcc) while solubility of carbon in γ-austenite phase is high. (4 marks)

(e) Explain three processes in which internal residual stresses may develop in metal and their alloys. (3 marks)

(f) State and explain any two stages of fatigue failure. (4 marks)

(g) Consider a material of cross-section A puled by force F. Derive the expression for true stress and strain of the element of the material at an instantaneous point. (4 marks)

(h) Explain normalising heat treatment as commonly applied to steel. (2 marks)

SECTION B – ANSWER ANY TWO QUESTIONS IN THIS SECTION

QUESTION TWO (20 MARKS)

(a) Determine the miller – bravais indices of plane A and B and directions C and D in Figure 1. (8 marks)

(b) A tensile stress is to be applied along axis of a cylinder brass rod that has a diameter of 10mm. determine the magnitude of the load required to produce a 2.5 x 10^{-3}mm change in diameter if the deformation is entirely elastic. Take the Poisson's ratio and elastic modulus of brass as 0.34 and 77 GPa respectively. (4 marks)

(c) With an aid of well labelled diagram show that the atomic packaging factor for FCC and BCC are 0.74 and 0.68 respectively. (8 marks)

QUESTION THREE (20 MARKS)

(a) Discuss three reasons why ferrous alloys are used so extensively and state their characteristic of ferrous alloys that limit their utilization. (6 marks)

(b) State and explain three major classification of polymers. (6 marks)

(c) A cylindrical specimen of steel having an original diameter of 12.8mm is tensile tested to fracture and found to have engineering fracture strength of 460 MPa. If its cross- sectional diameter of fracture is 10.7mm, determine:

i. The ductility in terms of percent reduction in area (2 marks)
ii. The true stress at fracture (3 marks)

(d) Differentiate between wrought and cast alloys. (2 marks)

(e) Give at least four examples of non- ferrous alloys. (2 marks)

QUESTION FOUR (20 MARKS)

Consider the lead and tin phase diagram shown in Figure 2 and drawn to scale.

a) State the various phase regions found on the lead-tin system. (2 marks)

b) What is the maximum solubility of lead in B- phase of tin? Indicate the temperature at this point? (2 marks)

c) What is the % composition of lead and tin and the temperature at the eutectic in variant point? (3 marks)

d) Determine the phases present, their composition and fraction using the levers rule at a temperature of 150 ℃ and 40 wt. % Sn. (6 marks)

e) Given the densities of Pb and Sn as 11.23g/cm^3 and 7.24g/cm^3, respectively determine the relative volume fraction of each phase. (4marks)