MUEO

MOI UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR
(ACADEMICS, RESEARCH & EXTENSION)

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATION

FOR THE DEGREE OF

BACHELOR OF ENGINEERING
IN
INDUSTRIAL & TEXTILE ENGINEERING

COURSE CODE: MIT 311

COURSE TITLE: MATERIAL SCIENCE

DATE: 20TH FEBRUARY, 2018 **TIME:** 2.00 P.M. – 5.00 P.M.

INSTRUCTIONS TO CANDIDATES

- SEE INSIDE.

THIS PAPER CONSISTS OF (3) PRINTED PAGES

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MIT 311: MATERIAL SCIENCE *2017/2018*

Instructions

1. This paper contains seven questions, all carrying equal marks.
2. Attempt any five questions.
3. Do not write anything on the question paper
4. Unauthorized electronic gadgets e.g. mobile phones, not allowed in the exam room.
5. Exam duration is 3 hours

Question 1

(a) Draw planes (112), (101), (111), and (123) in a unit cell. *4 marks*

(b) Indicate the atomic arrangements in (111) plane of face centre cubic structure and show the following directions [1-11], [-110], [-211] and [1-21]. *4 marks*

(c) The atomic radius of iron (Fe) is 0.124nm. Find the lattice parameter of Fe at room temperature. *4 marks*

(d) Describe the limitations of ferrous alloys compared to nonferrous alloys. *2 marks*

Question 2

(a) Show that the ideal c/a ratio in a hexagonal unit cell is 1.633 and calculate the packing efficiency. *8 marks*

(b) Describe the martensitic transformation in iron-carbon alloys. *6 marks*

Question 3

(a) With the aid of diagrams, differentiate between cubic and tetragonal crystal systems. *4 marks*

(b) The concentration of carbon in an iron-carbon alloy is 0.15 wt%. Compute the concentration in kilograms of carbon per cubic meter of alloy given the density of carbon and iron as 2.25 g/cm^3 and 7.87 g/cm^3, respectively. *4 marks*

(c) Using a hypothetical phase diagram, describe precipitation hardening. *6 marks*

Question 4

(a) Describe the differences between an edge and a screw dislocation. *5 marks*

(b) Derive the lever rule as applied in a completely miscible two-phase binary system. *5 marks*

(c) With the help of a diagram, show the relationship between resolved shear stress and applied axial stress in a perfect single crystal. *4 marks*

Question 5

(a) With reference to strain hardening phenomenon:

(i) Define and outline its effects. *3 marks*

(ii) Describe its working mechanism. *2 marks*

(iii) Explain the theory behind it. *1 mark*

(b) A test specimen in a tensile test has a gauge length of 50 mm and a cross-sectional area of 316 mm^2. During the test the specimen yields (0.2% offset) under a load of 140 kN. The corresponding gauge length is 50.2 mm. The maximum load of 200 kN is reached at a gauge length of 58 mm. Determine:

(i) Yield strength in MPa. *1mark*

(ii) Modulus of elasticity in GPa. *2 marks*

(iii) Tensile strength in MPa. *1 mark*

(iv) Percentage elongation if fracture occurs at a gauge length of 66 mm. *2 marks*

(v) Percentage area reduction (ductility) if the specimen necked to an area of 156 mm^2. *2 marks*

Question 6

(a) With the aid of a diagram, discuss the features of a completely miscible binary phase diagram. *6 marks*

(b) From the aluminium-copper (Al-Cu) binary phase diagram shown in **Fig. Q6**, determine:

(i) The volume fraction and composition of the solid at 600°C, assuming slow cooling. *3 marks*

(ii) The temperature at which solidification complete. *1 mark*

(iii) The fraction eutectic, assuming fast cooling. *3 marks*

(iv) The solidified microstructure observed following slow cooling *1 mark*

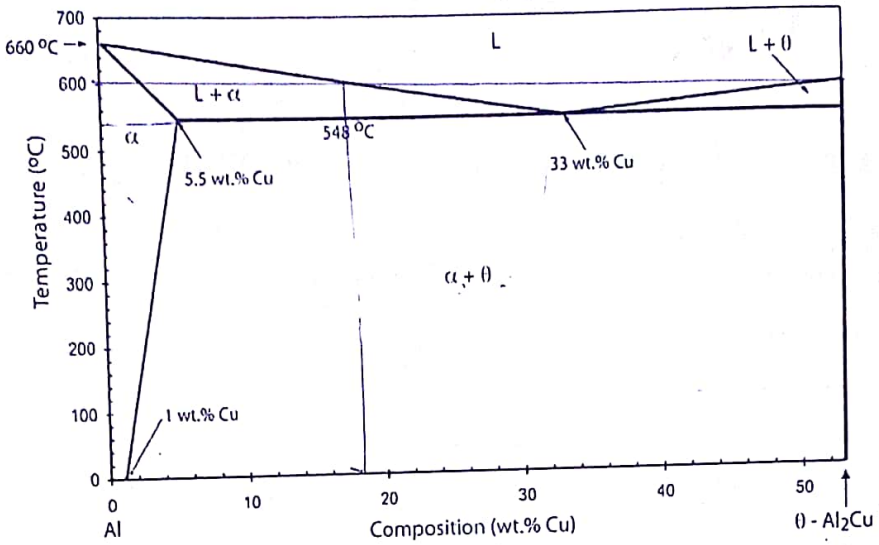

Fig. Q 6

Question 7

(a) Differentiate between congruent and incongruent phase transformations, and provide an example for each. *3 marks*

(b) State the Gibbs phase rule as applied in equilibrium phase diagrams. *2 marks*

(c) Using **Fig. Q7**, calculate the amount of each phase present in 1 kg of a 50 wt.% Pb- 50 wt.% Sn alloy at 300°C, 200°C and 100°C. In addition, determine the amount of each microstructure. *9 marks*

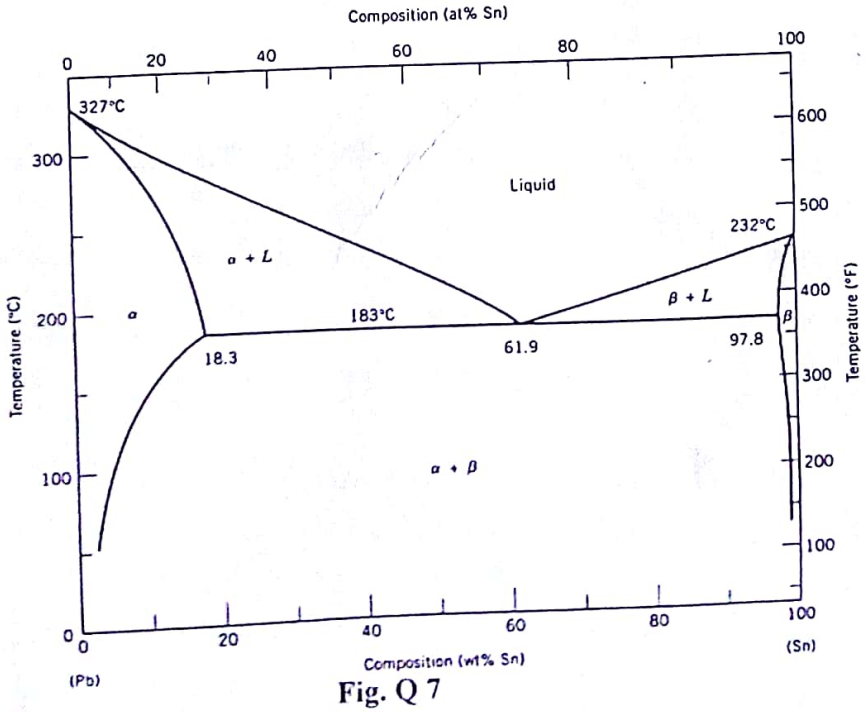

Fig. Q 7