Ref. No.: Ex/ME(M2)/PC/B/T/215/2024(S)

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2024

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours **Full Marks: 100**

(Answer any FIVE questions)

1(a) What are the different crystal systems and crystal structures? Explain any two types of crystal system with suitable geometrical diagram. (6+4)

1(b) Explain how Miller indices are determined for planes of simple cubic crystal structure. (5)

1(c) Calculate the atomic packing factor for BCC crystal structure. (5)

2(a) What is diffusion co-efficient for solid state diffusion? Mention the factors which influence diffusion co-efficient. Explain how it is determined experimentally. (2+3+3)

2(b) What is decarburization? Draw the concentration profile for decarburization process and solve the following problem.

A 0.85% carbon steel component has been decarburised at 950°C for a duration of 5 hours in an atmosphere equivalent to 0.2% carbon at the surface of the component. Calculate the percentage concentration of carbon at a depth of 0.35 mm from the surface of the component. (4+8)

Given: $D_o = 0.7\times10^{-4}\ \frac{m^2}{s}$; Q = 157 $\frac{KJ}{mol}$; R = 8.314 $\frac{J}{mol\ K}$

Z	0.25	0.30	0.35	0.40
erf(Z)	0.2763	0.3268	0.3794	0.4284

3(a) What do you mean by slip system? Determine the number of slip system of FCC unit cell for {111} family of planes. (2+4)

3(c) Determine the magnitude of applied tensile stress which needs to be applied along $[1\bar{1}1]$ axis of a single crystal to cause slip on the $(1\bar{1}0)$ [101] system. $\tau_{CRSS} = 15\ MPa$ (6)

3(c) Explain the concept of critical resolved shear stress. Show that yield stress is twice that of critical resolved shear stress. (4+4)

4(a) What is a composite material? Differentiate between composite material and alloy. Explain particle reinforced composite material with suitable examples. (2+4+4)

4(b) Derive the expression for 'critical length' of fibre in a fibre reinforced composite. Explain the stress-strain behaviour of FRC under longitudinal loading. (4+6)

5(a) Explain the origin of energy band structure in solids. (5)

5(b) Explain the Fermi-Dirac electron energy distribution function. Draw the function for temperatures 0 K, 300 K and 600 K for 'Silicon'. Also explain the dependence of conductivity on temperature with the help of the function. (3+3+3)

5(c) The resistivity of intrinsic semiconductor germanium at room temperature is 0.43 Ω-m. Calculate the intrinsic carrier density at room temperature and energy gap for germanium. (6)

Given data:

Number of electrons available for excitation near the top of valence band $= 5 \times 10^{25}\ per\ m^3$

Charge of electron $= 1.602 \times 10^{-19}$ Coulomb ; Mobility of electron $= 0.39\ \frac{m^2}{V.Sec}$

Mobility of hole $= 0.19\ \frac{m^2}{V.Sec}$; Boltzman constant $= 8.62 \times 10^{-6}\ \frac{eV}{K}$

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6(a) Draw the Iron-Iron carbide equilibrium phase diagram according to scale and label it. Explain eutectic, eutectoid and peritectic reactions with reference to this diagram. (8+6)

6(b) 20 kg of an alloy with 60% lead and 40% tin is slowly cooled from 300°C. Refer to the lead-tin phase diagram given in Figure-1 and determine the followings: (6)

(i) Weights of liquid phase and pro-eutectic solid phase just above the eutectic temperature

(ii) Weight of eutectic solid phase due to tin formed by eutectic reaction only

7(a) Draw the TTT diagram for eutectoid steel and mention the salient features of this diagram. (10)

7(b) Mention the objectives of heat treatment. How to perform normalizing and what are its effects on mechanical properties. (4+6)

8) Write short notes on the followings (any four): (4×5)

a) HCP crystal structure
b) Piezoelectricity and its applications
c) Hume-Rothery's rule
d) Schmid factor
e) Fermi energy level
f) Lever rule
g) Burger vector

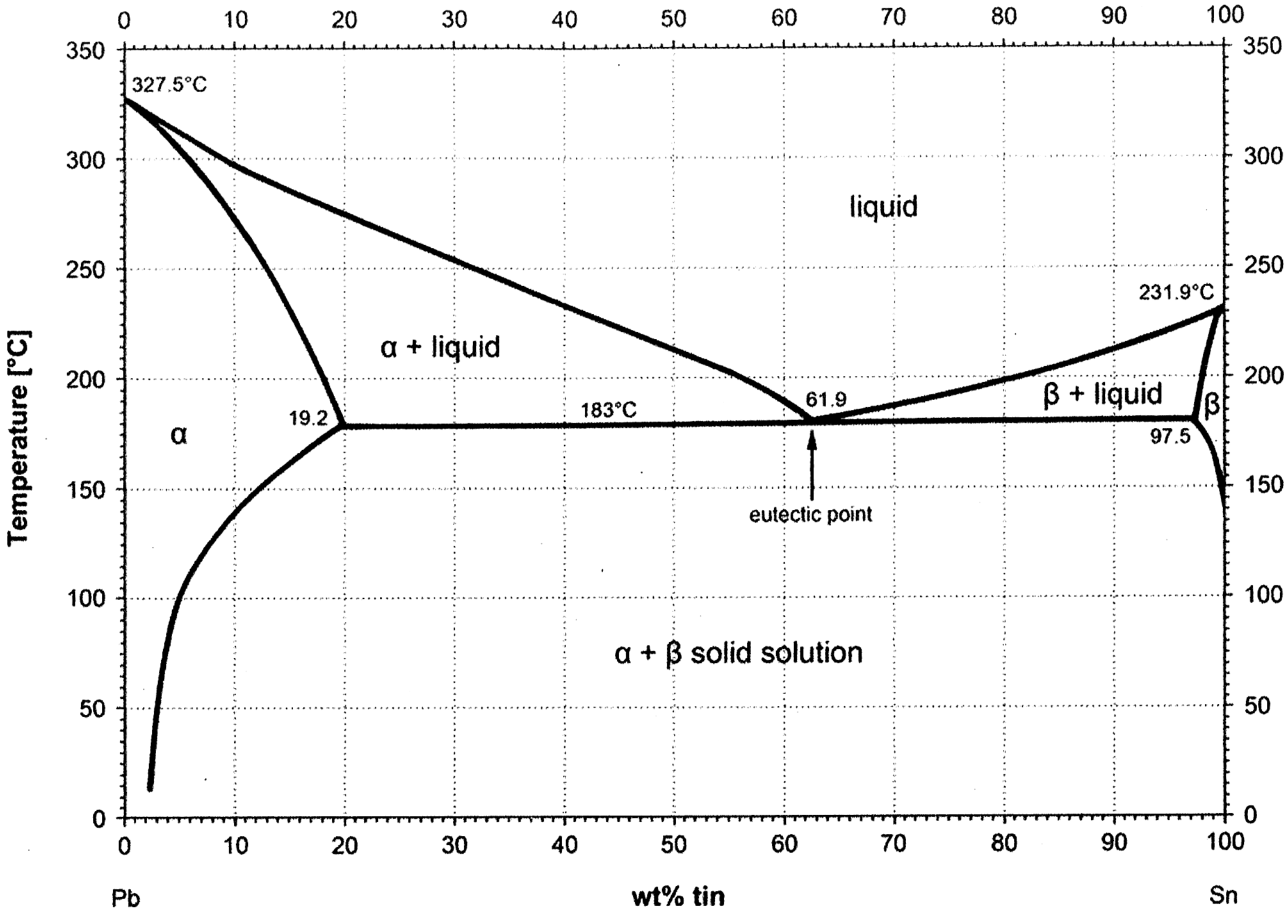

Figure-1: Pb-Sn phase