Ref. No.: Ex/ME/5/T/212/2024(S)

B.E. (MECHANICAL ENGG.) 2ND YEAR 1ST SEMESTER SUPPLEMENTARY EXAMINATION, 2024

MATERIALS SC. AND ENGG **Time: Three hours** **Full Marks: 100**

(Answer any FIVE questions)

1(a) Explain the following terms with reference to crystal structure: (10)

Basis, Unit cell, Space lattice, Crystal system

1(b) Draw the following crystallographic planes and directions:

(i) $(2\bar{2}\ 1)$ (ii) [213] (iii) $(23\bar{1})$ (iv) $[4\bar{1}\ 3]$

(6)

1(c) Determine the atomic packing factor for FCC crystal structure. (4)

2(a) State Fick's laws for solid state diffusion. Explain any one diffusion mechanism. (4+4)

2(b) Calculate the time required to carburise a steel with initial composition of 0.45 % carbon to 1.25 % carbon at a depth of 0.35 mm. Assume a constant surface concentration of 2.35 % carbon due to carburising atmosphere and carburising temperature as 950°C. (12)

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

Z	0.50	0.55	0.60	0.65
erf(Z)	0.5205	0.5633	0.6039	0.6420

3(a) Deduce Schmid's law of resolved shear stress and hence deduce the relation between critical resolved shear stress and yield stress. (4+4)

3(b) Considering Frenkel model of slip in perfect crystal, deduce the expression of theoretical shear strength. (6)

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)

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)

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

5(b) Explain the Fermi-Dirac electron energy distribution function explaining each term involved in 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. (4+3+3)

5(c) The resistivity of germanium at 25°C is 0.45 Ω-m. Calculate its resistivity at 325°C.
Given energy gap for germanium = 0.7 eV; Boltzman constant $= 86.2 \times 10^{-6} \frac{eV}{K}$ (5)

6(a) Draw Iron-Iron carbide equilibrium phase diagram and explain eutectic, eutectoid and peritectic reactions with reference to this diagram. (6+4)

6(b) 25 kg of an alloy with 55% lead and 45% tin is slowly cooled from 300°C. Refer to the lead-tin phase diagram given in Figure-1 and determine the followings: (3+3+4)

(i) Weights of liquid phase and pro-eutectic solid phase at 210°C

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

(iii) Weight of eutectic solid phase formed by eutectic reaction only

7(a) Draw the TTT diagram for eutectoid steel and mention the salient features of this diagram. (6+4)

7(b) What are the objectives of 'heat treatment'? Explain any two heat treatment processes in detail. (2+4+4)

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

a) HCP crystal structure

b) Orthorhombic crystal system

c) Diffusion co-efficient

d) Hume-Rothery's rule

e) Schmid factor

f) Fermi energy level

g) Lever rule

h) Burger vector

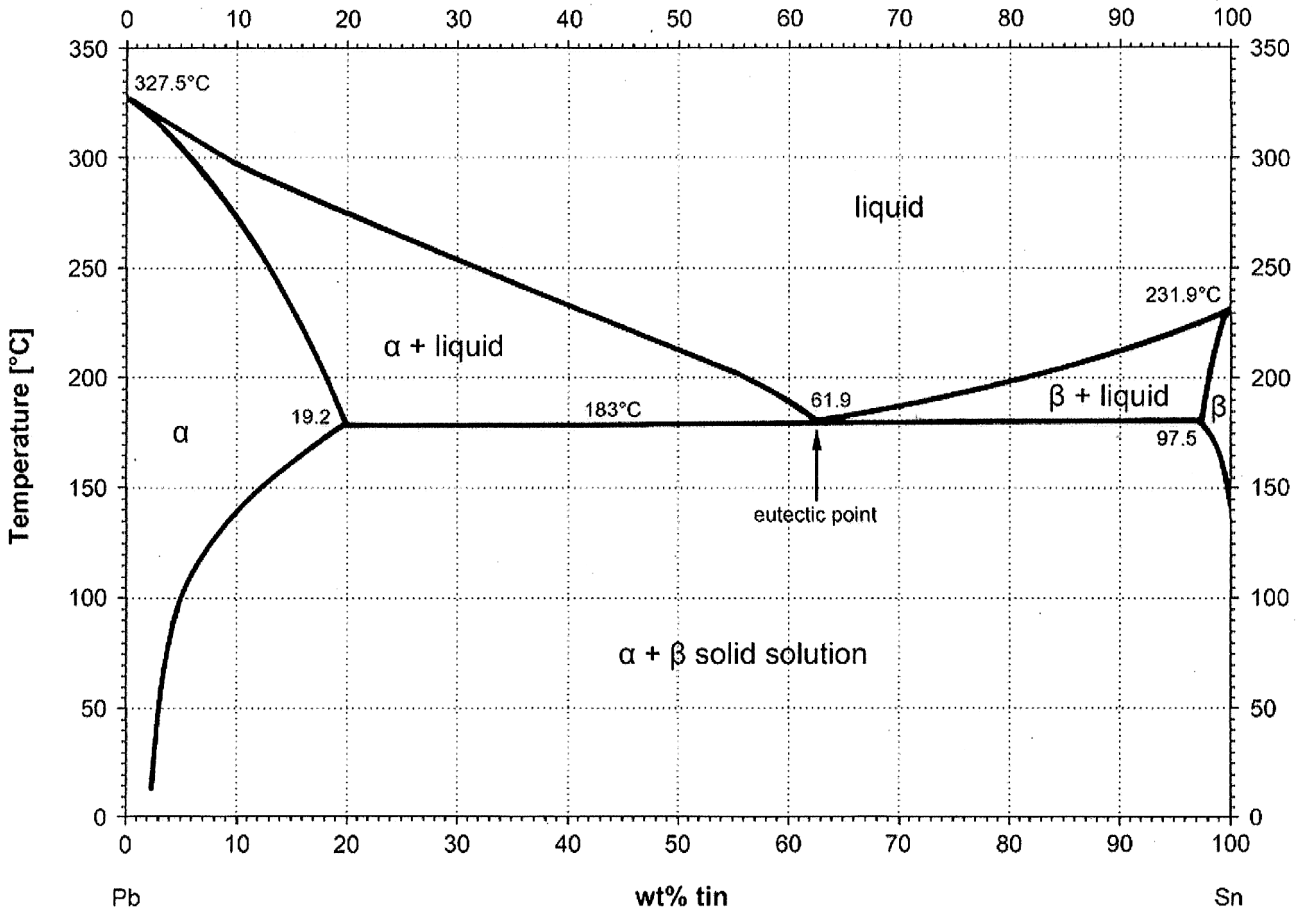

Figure-1: Pb-Sn phase diagram