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

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

MATERIAL SCIENCE AND ENGINEERING

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

(Answer any FIVE questions)

(Carefully note the questions denoted by "Or")

1(a) Explain the HCP crystal structure with sketch and determine its the atomic packing factor. (4+4)

1(b) Draw the following crystallographic planes and directions: (6)

(i) $(0\bar{1}2)$ (ii) [203] (iii) $(32\bar{1})$ (iv) $[2\bar{1}3]$

1(c) Calculate the planer densities of the planes (110) and (111) for Nickel from the following data: Nickel has FCC unit cell and its atomic radius is 1.245 Å. (6)

2(a) State Fick's laws for solid state diffusion. How will you estimate activation energy for solid state diffusion ? (4+4)

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

3(a) State and derive Schmid's law of resolved shear stress. Differentiate between resolved shear stress and critical resolved shear stress. (6+4)

3(b) Determine the number of slip system of FCC unit cell for {111} family of planes. (4)

A tensile stress is applied along [010] direction on a single crystal of BCC iron. Compute the resolved shear stress along (110) plane and in the direction $[\bar{1}11]$ when applied tensile is 52 MPa. (6)

4(a) Derive the expression for composite elastic modulus under iso-strain condition for a fibre reinforced composite (FRC) material. Also mention the assumption made to derive the expression. (6+4)

4(b) Derive the expression for 'critical length' of fibre in a fibre reinforced composite. Explain the stressstrain 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 = 5×10^{25} $per\ m^3$

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

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

Or

5(a) Compute the radius r of an impurity atom that just fits into a BCC octahedral site in terms of the atomic radius R of the host atom (without introducing lattice strains).

5(b) Discuss how dislocations are related to deformation.

5(c) Discuss mechanisms of strengthening in metals

5(d) Discuss metallic corrosion (5+5+5+5)

6(a) Draw the Iron-Iron carbide equilibrium phase diagram according to scale and label it. (10)

6(b) 12 kg of an alloy with 67% lead and 33% 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 phaseand pro-eutectic solid phasejust above the eutectic temperature

(iii) Weight of eutectic solid phasesdue to lead and tin formed by eutectic reaction only

Or

6 (b) Consider 3.5 kg of austenite containing 0.95 wt%C and cooled to below 727 °C.

(i) What is the pro-eutectoid phase?

(ii) How many kilograms each of total ferrite andcementite form?

(iii) How many kilograms each of pearlite and thepro-eutectoid phase form? (3+3+4)

7(a) Draw the TTT diagram for eutectoid steel and mention the salient features of this diagram. (12)

7(b) Write short notes (any two): (8)

i) Annealing ii) Normalizing iii) Hardening

Or

7 (b) In T-T-T diagry7am, show how with varying cooling rates different phases appear. (8)

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

a) Miller-Bravais indices

b) Piezoelectricity

c) Hume-Rothery's rule

d) Line dislocation

e) Fermi energy level

f) Martempering

g) Lever rule

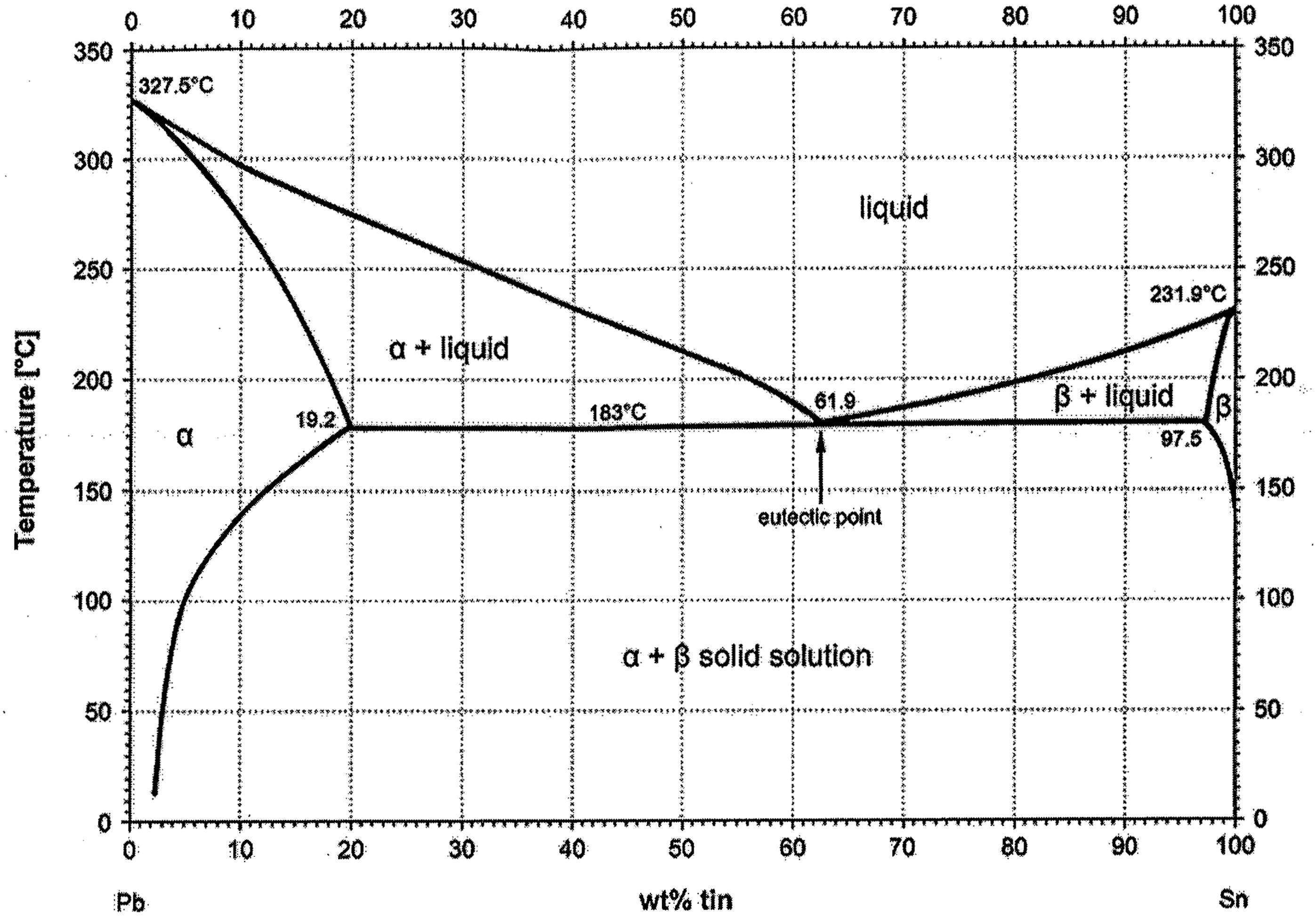

Figure-1: Pb-Sn phase diagram