Ref. No.: Ex/ME(M2)/PC/B/T/215/2023(S)

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM - 2023

Subject : MATERIAL SCIENCE AND ENGINEERING **Time : 3 Hrs** **Full Marks :100**

(Answer any FIVE questions)

1a) Mention different types of ferrous materials. Explain the composition of cast iron and steel.Also compare their mechanical properties. (4+4+4)

b) Draw stress-strain diagram of the following materials on a single graph paper: (8)

Mild steel, Cast Iron, Aluminium, Diamond

Or

1 a) Differentiate between 'resolved shear stress' and 'critical resolved shear stress'. (4×5=20)

b) What are slip systems?

c) What is strain hardening?

d) What is burger vector?

2a) Draw the following crystallographic planes and directions: (8)

$(\bar{3}2\bar{1})$ [112] $(\bar{2}10)$ [201]

b) Determine the atomic packing factor for hexagonal closed packed (HCP) crystal structure. (6)

c) Calculate the planer density of Nickel in SI unit along the plane (111). Nickel has FCC crystal structure with atomic radius 1.245 $\mathring{A}$. (6)

3a) Define 'activation energy' for solid state diffusion. How will you estimate activation energy ? (2+4)

b) Explain the steps of experimental determination of diffusion coefficient (D). (6)

c) The fraction of vacant aluminium lattice sites at 350°C is 4.25×10^{-6}.Calculate the number of point defects formed in an aluminium specimen at 625°C.

Given, The total number of lattice sites in the specimen =8.65×10^{14}. Activation energy per atom = 0.76 eV

Boltzman constant =$86.2 \times 10^{-6} \frac{eV}{K}$ (8)

Or

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3 a) Consider one such alloy that initially has a uniform carbon concentration of 0.25 wt% and is to be treated at 9508^{0}C. If the concentration of carbon at the surface is suddenly brought to and maintained at 1.20 wt%, how long will it take to achieve a carbon content of 0.80 wt% at a position 0.5 mm below the surface? The diffusion coefficient for carbon in iron at this temperature is 1.6×10^{-11} m^2/s; assume that the steel piece is semi-infinite.

Use the following table if required.

z	erf(z)
0.25	0.2763
0.3	0.3286
0.35	0.3794
0.4	0.4284

b) What is yielding? Discuss the difference between true stress, true strain and engineering stress and engineering strain.

c) A cylindrical specimen of steel having an original diameter of 12.8 mm is tensile tested to fracture and found to have an engineering fracture strength σ_f of 460 MPa. If its cross-sectional diameter at fracture is 10.7 mm, determine ductility in terms of percentage reduction in area. (10+6+4)

4a) What is 'critical length of fibre' for fibre reinforced composite (FRC) material.Derive its expression. (3+5)

b) For a fibre reinforced composite material, the modulus ratio is 35 and the fibre takes 28% of the cross sectional area. What percentage of the longitudinal load is taken by the fibre ? (6)

c) Explain the load transfer mechanism in a fibre reinforced composite (FRC) materialunder longitudinal loading. (6)

5a) Draw the Iron-Carbon equilibrium phase diagram according to scale and label it. (12)

5b) Explain eutectic, eutectoid and peritectic reactions with reference to Iron-Carbon equilibrium diagram. (8)

6a) Explain the construction and salient features of TTT diagram for a ferrous material. (12)

b) A 0.8% carbon eutectoid steel is slowly cooled from 750°C to a temperature just below 723°C. Assuming that the austenite is completely transformed to α-ferrite and cementite, calculate the weight percent of eutectoid ferrite and weight percent of eutectoid cementite formed. (8)

7a) Explain how the 'energy band structure' in solids is developed. Differentiate among conductors, semiconductors and insulators in the light of energy band structure. (4+6)

b) 'Intrinsic semiconductors arebasically insulators at low temperatures' ------ Explain. (4)

c) Write the Fermi-Dirac electron energy distribution function explaining each term involved in the expression. Draw the function for temperatures 0 K, 200 K, 600 K and 900 K. (6)

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

a) Classification of engineering materials

b) Diffusion mechanism

c) Fick's laws of diffusion

d) Energy band gap

e) Lever rule

f) Metal matrix composite

g) Particle reinforced composites