

Note: Attempt all parts of a question together. Assume any missing data suitably.

Q.1 (a) Draw a labelled hypothetical two component (A & B) phase diagram from the following data: (10)

- i. Melting point of A and B are 1100 °C and 900 °C respectively
- ii. Maximum solid solubility of A in B is 12% and B in A is 8 % at invariant temperature i.e. 750 °C, the solubility drop down to zero in both the cases at room temperature.
- iii. The eutectic reaction takes place at 68% of B.

(b) From the above constructed phase diagram, for an overall composition of 75% A, determine (2+4)

- i. the fraction of liquid and solid phases at 800 °C.
- ii. the fraction of primary α, fraction of eutectic α and fraction of eutectic β phases at 730 °C.

(c) Write (i) Peritectic reaction (ii) Eutectoid reaction (2+2)

Q.2 (a) Draw the M-H curves for type I and type II superconductors below their critical temperature(s). (4)

(b) Fe undergoes allotropic transformation from BCC to FCC at 910 °C. Calculate the % volumetric change during the transformation. Given lattice parameters, $a_{BCC} = 1.258 \text{ \AA}$ and $a_{FCC} = 1.292 \text{ \AA}$. (4)

(c) Define uniform corrosion and list two prevention methods for it. (4)

(d) Write the equation and calculate the stress required to move a dislocation if the width of the dislocation is twice of the magnitude of the burgers vector. (4)

Q.3 (a)

- i. Explain how grain size of a polycrystalline material affects its yield strength. Also mention the mathematical relation between them. (5+4)
- ii. Estimate the change in yield strength of a polycrystalline material when its ASTM grain size increased from 4 to 8. Assume yield strength at infinite grain size, $\sigma_i = 80 \text{ MN/m}^2$ and Hall-Petch constant, $k = 0.63 \text{ MN/m}^{3/2}$.

(b) Explain why Al is not suitable for light weight air borne structures while its composite with Boron is. Calculate the modulus of Al (70%)-B(30%) composite; Given: Young's modulus of Al=71 GPa; B=440 GPa. (3+3)

(c) A cylindrical specimen of steel having an original diameter of 14 mm is tensile-tested to fracture and found to have engineering fracture strength of 500 MPa. If its cross-sectional diameter at fracture is 12 mm, determine the true stress at fracture. (5)

- p-34
- Q.4** (a) Draw a planar view of diamond cubic structure and calculate its packing efficiency. (5)
(b) In an ideal HCP unit cell, draw $(01\bar{1}0)$ plane and calculate its planner density. (5)
Given, the atomic radius is 1.31 \AA .
- (c) The Bragg angle (2θ) corresponding to a reflection for which $(h^2+k^2+l^2) = 8$ is observed at 14.35° for a cubic crystal. Determine the lattice parameter of the crystal if the X-ray wavelength is 0.71 \AA . (4)
- Q.5** (a) Draw a labeled polarization vs. frequency plot for PbTiO_3 in audio to optical frequency range. Which polarization mechanism, if any is absent in it? Justify your answer. (4+2)
(b) Draw labelled M-H loops for (i) AlNiCo and (ii) Ni-Zn ferrite. Which will have higher energy product and why? (6)
(c) Show that electrical conductivity of a metal is proportional to the average collision time of electrons. (4)
(d) Calculate the room temperature conductivity of pure Ge. The concentration of holes is $n_h = 1.01 \times 10^{14} \text{ cm}^{-3}$ and mobility of electrons and holes is $0.39 \text{ m}^2/\text{V.s}$ and $0.19 \text{ m}^2/\text{V.s}$ respectively. (4)
- Q.6** Briefly explain why (Limit your answer to 20-30 words) (10)
i. Glazing is done for ceramic insulators.
ii. Fe is ferromagnetic while Mn is not.
iii. Platinum is used in resistance thermometers.
iv. Graphite is used as a lubricant while diamond is not.
v. Ionic crystals have large burger vector.