

2023
B.E. (Mechanical Engineering)
First Semester
ASPX03: Physics of Materials
(Common with Biotech, IT and CSE)

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Part.

x-x-x

I. Attempt any five parts (2 x 5=10)

- (a) Sketch within a cubic unit cell the following planes:
(i) $(0\bar{1}\bar{1})$ (ii) $(10\bar{2})$
- (b) Why X-rays are used in crystallographic analysis?
(c) What is viscoelasticity?
(d) Differentiate between resolved shear stress and critical resolved shear stress.
(e) How does the strength of metal improve by grain size reduction?
(f) What is/are the driving force/s for the phase transformation?

Part A

- II. (a) The potential energy of interaction between two atoms forming a molecule is given by the expression $U(r) = \frac{-A}{r^m} + \frac{B}{r^n}$. Show that the cohesive energy of the molecule can be expressed as $U_{min} = \frac{-A}{r_0^m} \left(1 - \frac{m}{n}\right)$.
(b) Evaluate the planar density of (111) plane in FCC unit cell.
(c) What are carbon nanotubes? How do you classify the carbon nanotubes based on their chirality. (5,2,3)
- III. (a) Derive Fick's 2nd law of diffusion. Discuss the factors affecting diffusion process?
(b) Rank the magnitudes of the diffusion coefficients from greatest to the least for the following systems: (i) N in Fe at 700°C (ii) Cr in Fe at 700°C (iii) N in Fe at 900°C (iv) Cr in Fe at 900°C. (6,4)
- IV (a) Sketch the time-strain curve for anelastic behaviour and compare it with the time-strain curve in the Voigt-Kelvin element. What do you deduce from this?
(b) A tensile load of 100 N is applied to an aluminium-boron composite of 1 mm² cross-sectional area. The volume of the parallel fibres is 30%. What is the stress in the fibres, when the load axis is (i) parallel to the fibres, and (ii) perpendicular to the fibres? (6,4)

Part B

- V. (a) What do you understand by slip system? Describe the mechanism of slip in a single crystal.
- (b) What do you understand by the term fracture? What are the possible causes of fractures? Discuss the principle and mechanism of brittle fracture.
- (5,5)
- VI. (a) Consider a binary isomorphous solution of copper and nickel. Discuss different microstructures developed during non-equilibrium cooling.
- (b) What is Gibb's phase rule? Discuss its significance.
- (7,3)
- VII. (a) Explain the heterogeneous nucleation process using free energy change. Find the critical radius, r^* for heterogeneous nucleation.
- (b) Cite the differences between pearlite, bainite and spheroidite relative to microstructure and mechanical properties.
- (5,5)