MATERIAL SCIENCE AND TECHNOLOGY
(AEIE 2111)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) High dielectric constant material is must for
(a) Insulation of wires (b) Motors
(c) Switch bases (d) Generators

(ii) If a material is subjected to two incremental true strains namely ε_1 and ε_2, then the total true strain is
(a) $\varepsilon_1 * \varepsilon_2$ (b) $\varepsilon_1 - \varepsilon_2$
(c) $\varepsilon_1 + \varepsilon_2$ (d) $\varepsilon_1 / \varepsilon_2$

(iii) Optical fibre operates on the principle of
(a) Total internal reflection (b) Tyndall effect
(c) Photo-electric effect (d) Laser technology

(iv) The following ceramic product is mostly used as pigment in paints
(a) TiO_2 (b) SiO_2
(c) UO_2 (d) ZrO_2

(v) Hardness during over-aging
(a) Decreases (b) Increases
(c) Constant (d) Decreases abruptly

(vi) Following strengthening mechanism applies to multi-phase material
(a) Grain size reduction (b) Dispersion hardening
(c) Strain hardening (d) Solid solution strengthening

(vii) Brittle fracture is more dangerous than ductile fracture because _____.
(a) No warning sign
(b) Crack propagates at very high speeds
(c) No need for extra stress during crack propagation
(d) All of the above

(viii) Difficult to monitor and very dangerous form of corrosion
(a) Galvanic (b) Pitting
(c) Crevice (d) Stress

(ix) Stainless steel is so called because of its _____.
(a) High strength (b) High corrosion resistance
(c) High ductility (d) Brittleness

(x) Repeatable entity of a crystal structure is known as
(a) Crystal (b) Lattice
(c) Unit cell (d) Miller indices

Group – B

2. (a) Explain the difference among conductors, semiconductors and insulators and give typical values of conductivity for a conductor, a semiconductor and an insulator.

(b) Explain why conductivity of a semiconductor usually increases while that of a metal decreases with increasing temperature.

(c) Examine the atomic packing factors (APF) of simple cubic, body centred cubic and face centred cubic structures.

(3 + 3) + 3 + 3 = 12

3. (a) Iron has cubic structure and its atomic weight is 55.84. The density of iron is 7900 kg/cm^3 and its lattice constant is 2.86 Å. Examine the type of cubic structure.

(b) With reference to the atomic structure of the material, identify the characteristics which govern the physical and chemical properties of atoms.

(c) Identify the Miller indices of a plain which intercepts at a, b/2, 3c in a simple cubic unit cell.

3 + 6 + 3 = 12

Group – C

4. (a) Prove that, $\sigma_x = \frac{E}{1+\nu}\varepsilon_x + \frac{\nu E}{(1+\nu)(1-2\nu)}(\varepsilon_x + \varepsilon_y + \varepsilon_z)$, where

σ_x = linear stress along x-direction, E = Young's modulus,
ν = Poisson's ratio and ε_x, ε_y, ε_z = natural strain along x, y, z directions.

(b) Explain the terms: proportional limit, elastic limit and fracture limit in a stress-strain curve.

(c) Inspect surface defects in crystalline solids.

6 + 3 + 3 = 12

5. (a) Draw the steel region of the Fe-Fe_3C phase diagram and make neat sketches of the microstructures expected for four components between 0.0 and 1.2% of C.

(b) The length of a dislocation line between two pinning points is on an average equal to reciprocal of the square root of dislocation density in a crystal. Calculate the dislocation density in Cu, work hardened to a stage where slip occurs at a shear stress of 35 MN/m^2. (Given, shear modulus and Burgers vector of dislocations in Cu are 44 GN/m^2 and $3.61/\sqrt{2}$ Å respectively).

7 + 5 = 12

Group – D

6. (a) Analyze with neat drawing binary phase diagram of eutectic system. Differentiate between intermediate solid solution and terminal solid solution.

(b) Calculate the critical radius of particles due to nucleation of ice from water at (i) – 5^0C and (ii) -40^0C. The enthalpy of fusion of ice is 6.02KJ/mol. The energy of the ice-water interface, 0.076 J/m^2, can be taken to be independent of temperature and the molar volume of ice is 19 cm^3.

(6 + 3) + 3 =12

7. (a) For molybdenum, the temperature and strain rate dependence of yield stress in MN/m^2 is given by:

$$\sigma_y = 20.6 + \frac{173000}{T} + 61.3\log_{10} e$$

Where 'T' is temperature in Kelvin and 'e' is the strain rate in sec^{-1}. Sharp cracks of half length 2 μm are present in the metal. If E = 350 GN/m^2 and specific energy is 2 J/m^2, estimate the temperature at which the ductile to brittle transition occurs at a strain rate of (i) 10^{-2} per sec and (ii) 10^{-5} per sec.

(b) At atmospheric pressure, a material of unknown composition shows four phases in equilibrium at 710^0C. Determine the minimum number of components in the system.

(c) The crack length of a certain material is 4.4 μm and the Young's modulus of the material is 60 GN/m^2. The surface energy is 1.32 J/m^2. Calculate the fracture strength and compare it with the Young's modulus.

6 + 2 + 4 = 12

Group – E

8. (a) Differentiate between addition and condensation polymerization mechanisms. List the factors determine the mechanical behavior of polymers.

(b) Categorize the degradation mechanisms in polymers.

(c) Explain life cycle analysis of engineering products.

(3 + 3) + 3 + 3 = 12

9. (a) A continuous and aligned glass reinforced composite consists of 40 vol% of glass fibres having modulus of elasticity of 69 GN/m^2 and 60 vol% of a polyester resin having modulus of elasticity of 3.4 GN/m^2. If the area of the composite is 210 mm^2 and a stress of 50 MN/m is applied in the longitudinal direction, compute the magnitude of the load carried by each of the fibre and the matrix phases.

   (b) List the properties and applications of refractory metals.

5 + (3 + 4) = 12

Department & Section	Submission Link
AEIE	https://classroom.google.com/c/MTg0NjQ4MDQzMDcy/a/MjcxMzc5NDA5NjU3/details