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) Which one of the following is **NOT** a strong bond?
(a) van der Waals bond (b) Covalent bond
(c) Metallic bond (d) Ionic bond.

(ii) Visible light's wavelength range:
(a) 0.39 – 0.77 mm (b) 0.39 – 0.77 μm
(c) 0.39 – 0.77 nm (d) 0.39 – 0.77 cm.

(iii) Coordination number in simple cubic crystal structure
(a) 1 (b) 2 (c) 3 (d) 4.

(iv) Following is not the 2-dimensional imperfection
(a) Twin boundary (b) Dislocation
(c) Surface (d) Grain boundary.

(v) Example for strengthening mechanism in single-phase material
(a) Strain hardening (b) Precipitation hardening
(c) Fiber strengthening (d) ispersion strengthening.

(vi) Fracture stress (σ_f) is proportional to
(a) crack length (b) 1/crack length
(c) $(\text{crack length})^{1/2}$ (d) $(\text{crack length})^{-1/2}$.

(vii) Gibbs phase rule for general system:
(a) P+F=C-1 (b) P+F=C+1 (c) P+F=C-2 (d) P+F=C+2.

(viii) Time dependent yield is known as
(a)Fracture (b)Fatigue (c) Buckling (d) Creep.

(ix) Not a characteristic property of ceramic material
(a) high temperature stability (b) high mechanical strength
(c) low elongation (d) low hardness .

(x) Al-alloys for engine/automobile parts are reinforced to increase their
(a) Strength (b) Wear resistance
(c) Elastic modulus (d) Density

Group – B

2. (a) Determine the number of atoms per cm^3 for ice and graphite. (Given the density of ice and graphite as of 1.8 g/cm^3 and 1 g/cm^3 respectively).

(b) Explain thermal expansion and define co-efficient of thermal expansion.

(c) List the applications of LASERs and optical fibers.

(3+2) + (2+1) + 4= 12

3. (a) Compare among diamagnetic, paramagnetic and ferromagnetic materials with specific examples of each type.

(b) The resistivity of pure silicon at room temperature is 3000 Ωm. Determine the intrinsic carrier density.(given mobility of electrons and holes in silicon at room temperature are 0.14 & 0.05 $m^2V^{-1}s^{-1}$ respectively).

(c) Construct the relationship between current density and average drift velocity.

(d) Evaluate the dielectric constant of a barium titanate crystal, which, when inserted in a parallel plate condenser of area 10 mm × 10 mm and distance of separation of 2 mm, gives a capacitance of 10^{-9} F.

(3+3) + 2+ 2 + 2 = 12

Group – C

4. (a) Establish the relation between (i) true stress & engineering stress and (ii) natural strain & engineering strain.

(b) Compute the line energy of dislocation in BCC iron. The burgers vector in iron is of the ½<111> type. The shear modulus of iron is 80.2 GN/m^2. (the lattice parameter of BCC iron is 2.87 Å)

(c) Explain the Maximum Shear stress yield criterion.

(d) Calculate the Poison's ratio and bulk modulus of stainless steel 304. (given, Young's modulus and shear modulus of SS304 are 190GPa and 74 GPa respectively)

(2 + 2)+ 3 + 3 +(1 + 1) = 12

5. (a) In a diffusion process Ni is diffused in Fe. If the diffusion temperature is 400^0C, calculate its diffusivity. (Given, $D_0 = 2.6 \times 10^{-4}$ m^2/s & Q = 295 kJ/mol).

(b) Compare steady-state and non-steady-state diffusion.

(c) Differentiate between slip and twining.

(d) The dislocation density in a Cu sample is increased by cold working from 10^9 m/m^3 to 10^{13} m/m^3. Determine the free energy change during recrystallization.

3+ 3 +3 + 3 = 12

Group – D

6. (a) Draw unary phase diagram of water and explain it. Indicate the steps to find equilibrium concentration of phases and equilibrium relative amount of phases.

(b) Calculate the critical free energy of 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.

(4 + 4) + 4 = 12

7. (a) The Young's modulus of a certain material is 180 GN/m^2 and its true surface energy is 1.44 J/m^2. The crack length is 4 µm. Calculate its fracture strength. If the actual fracture strength is 1.1 GN/m^2, comment upon the result.

(b) Analyze the stages of brittle fracture.

6 + 6 = 12

Group – E

8. (a) How steels are classified based on carbon content? Categorize stainless steels based on constituents of the microstructure.

(b) Classify ceramics based on their compositions.

(c) Calculate the volume ratio of aluminium and boron in Al-B composite which can have the Young's modulus equal to that of iron. The Young's modulus of Al, Fe and b are 71, 210, 440 GN/m^2 respectively.

(3 + 3) + 2 + 4 = 12

9. (a) Compare between thermoplastic and thermosetting materials. List molding techniques employed in fabrication of polymers.

(b) Classify the corrosion in metals.

(c) Explain recycling of materials.

(3 +3)+ 4 + 2 = 12