MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

*All parts of a question (a, b, etc.) should be
answered at one place.*

*Answer should be brief and to-the-point and be supple-
mented with neat sketches. Unnecessary long answer may
result in loss of marks.*

*Any missing or wrong data may be assumed suitably
giving proper justification.*

Figures on the right-hand side margin indicate full marks.

Group A

1. (a) Classify engineering material from various view
    point. Differentiate between steel and iron, alloys and
    composite and ceramics and polymers.   5

    (b) What are different types of ceramics? Name *any
    five* ceramics and write their properties and appli-
    cation.   5

    (c) (i) There is 5% probability for an electron to
        occupy an energy state which is 0.4 eV above
        the Fermi energy. Estimate the temperature at
        which this can happen.   7

    (ii) The dielectric strength of a natural rubber is
        40000 V/mm at 60 Hz. Calculate the thick-
        ness of insulation on a wire carrying 33 kV to
        sustain the breakdown.   3

2. (a) What is slip plane ? How it is related to dislocation ? Explain with the help of a diagram, the slip plane and slip direction in FCC, BCC and HCC and HCP crystals.   5

(b) Describe the process of decomposition of austenite to the following : 2.5×4

   (i) Pearlite

   (ii) Ferrite

   (iii) Bainite

   (iv) Retained austenite

(c) Explain the working of TTT diagrams and what information is supplied by them ?   5

3. (a) What is the necessity of knowledge true stress-strain diagram ? What are the utilities of these curves in tension, while the opposite is correct in compression — why ? $5 + 5$

(b) Explain the mechanisms involved in creep occurrence. Suggest material to prevent or minimize creep in metals and non metals.   5

(c) Justify with reason whether ball bearing should be oil hardened or water quenched.   5

4. (a) Write a short note on the Bauschinger effect. What is strain hardening and state the effect of state hardening. $5 + 5$

(b) Explain mechanism of dislocation in plastic deformation with neat sketches.   5

(c) Explain the yield point phenomenon in material in term of dislocation.   5

Group B

5. (a) Use Fick's first law to derive an expression for growth rate of pearlite nodule.   6

(b) A piece of steel which was quenched after prolonged holding at 700 °C was found to have ferrite martensite structure. Explain when would you expect this to happen ?   6

(c) Explain why thicker sections are more susceptible to cracking during hardening heat treatment.   4

(d) Hardness of a quenched and tempered steel is reported to be RC 35. What additional test will you recommend to know that it has indeed been given this heat treatment ?   4

6. (a) For the $MgO-Al_2O_3$ system, what is the maximum temperature that is possible without the formation of a liquid phase ? At what composition or over what range of compositions will this maximum temperature be achieved ?   5

(b) Explain why residual thermal stresses are introduced into a glass piece when it is cooled.   5

(c) Explain how density, firing distortion, strength, corrosion resistance and thermal conductivity are affected by the extent of vitrification.   5

(d) Compare the manner in which the aggregate particles become bonded together in clay-based mixtures during firing and in cements during setting.   5

7. (a) Briefly explain how each of the following influences the tensile modulus of a semicrystalline polymer and why :

   (i) Molecular weight

(ii) Degree of crystallinity

(iii) Deformation by drawing

(iv) Annealing of an undeformed material

(v) Annealing of a drawn material.   6

(b) Write an essay on polymeric materials that are used in the packaging of food products and drinks. Include a list of the general requisite characteristics of materials that are used for these applications. Now cite a specific material that is utilized for each of three different container types and the rationale for each choice.   4

(c) List several advantages and disadvantages of using transparent polymeric materials for eyeglass lenses. Cite four factors that determine what fabrication technique is used to form polymeric materials.   5

(d) A continuous and aligned glass fiber-reinforced composite consists of 40 volume % of glass fibers having a modulus of elasticity of 69 GPa and 60 volume % of a polyester resin that when hardened. displays a modulus of 3.4 GPa.

(i) Compute the modulus of elasticity of this composite in the longitudinal direction.

(ii) If the cross-sectional area is 250 mm² and a stress of 50 MPa is applied in this longitudinal direction. compute the magnitude of the load carried by each of the fiber and matrix phases.

(iii) Determine the strain that is sustained by each phase when the stress in part (ii) is applied.   5

8. (a) Estimate the maximum and minimum thermal

conductivity values for a cermet that contains 90 volume% titanium carbide (TiC) particles in a nickel matrix. Assume thermal conductivities of 27 and 67 W/m-K for TiC and Ni, respectively.   5

(b) Write an expression for the modulus of elasticity for a hybrid composite in which all fibers of both types are oriented in the same direction.   5

(c) Briefly explain why the magnitude of the saturation magnetization decreases with increasing temperature for ferromagnetic materials and why ferromagnetic behavior ceases above the Curie temperature.   5

(d) Calculate the (i) saturation magnetization and (ii) saturation flux density for nickel, which has a density of 8.90 g/cm³.   5

Group C

9. Answer the following in brief:

(i) Obtain the Miller indices of a direction which is common to the planes (110) and (120) inside a cubic unit cell.   2

(ii) Determine the interplaner spacing between (200), (220) and (111) planes in a FCC crystal. The atomic radius is 1.246 Å.   2

(iii) Write short notes on :   2 × 5

(a) Magnetization

(b) Susceptibility

(c) Bohr magneton

(d) Curie constant

(e) Neel temperature

(iv) Explain application of carbon nano tube. 2

(v) Define industrial application of composite material. 2

(vi) Classify reinforced composite elaborately. Why are they known as composite? 2