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 answers
may result in loss of marks.*

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

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

Group A

1. (*a*) Explain semiconductor, intrinsic and extrinsic
   semiconductors.   6

   (*b*) Mention four strengthening mechanisms of metals
   and alloys, and explain any one of them.   4

   (*c*) Why are metals mostly ductile and ceramics brittle
   at room temperature ?   10

2. (*a*) What are the invariant points (degrees of freedom = 0)
   in a binary phase diagram with eutectic ?   3

   (*b*) Explain the terms isomorphous, eutectic, peritectic
   and eutectoid systems.   8

(Turn Over)

(c) Explain how will you determine the elastic and plastic components of strain from a schematic stress-strain curve, showing loading and unloading in plastic strain range.   3

(d) Define the following terms :   3 × 2

    (i) Yield strength

    (ii) Tensile strength

    (iii) Poisson's ratio.

3. (a) Explain the mechanism of creep.   8

(b) Distinguish between ductile and brittle fracture.   4

(c) What do you mean by normalizing and tempering, and indicate how those heat treatments affect the properties of steel ?   4

(d) A sodium silicate glass has no surface defects as etching has removed them, but has cracks inside from 2 μm to 5 μm in length . Calculate the surface energy of glass if fracture strength = $100 \, \mathrm{MNm^{-2}}$; Young's modulus = $70 \, \mathrm{GNm^{-2}}$.   4

4. (a) Write a note on viscoelastic properties of materials, showing schematic plots of variation of stress with strain and strain with time.   6

(b) Differentiate between edge and screw dislocation.   4

(c) Explain cold working, warm working and hot working.   6

(d) What is Bauschinger effect ?   4

Group B

5. (a) Discuss the mechanism of age hardening of Al alloys.   5

(b) How is hardenability test carried out ?   5

(c) Discuss the heat transfer characteristics during quenching, and its effect on mechanical properties.   5

(d) Discuss the nitriding process.   5

6. (a) What are the effects of high temperature on mechanical properties of metals.   3

(b) What will be your considerations for choice of an alloy for high temperature applications.   4

(c) A continuous and aligned glass fiber reinforced composite consists of 40 vol% of glass fibres having a modulus of elasticity 69 GPa and 60 vol% of a polyester resin that, when hardened, displays a modulus of 3·4 GPa. Calculate the modulus of elasticity of this composite in the longitudinal directions.   7

(d) Discuss zone theory of solids and explain zones in conductors and insulators.   6

7. (a) A transformer core is wound with a coil carrying an alternating current at a frequency of 50 Hz. Assuming the magnetization to be uniform throughout core volume of $0·02 \, \mathrm{m^3}$, calculate the hysteresis loss. The hysteresis loop has an area of 80,000 units, when the axes are drawn in units of $10^{-4} \, \mathrm{Wbm^{-2}}$ and $10^{-2} \, \mathrm{Am^{-1}}$.   6

(b) Distinguish between soft and hard magnets.   4

(c) Write the peritectic, eutectic and eutectrial reaction of Fe-Fe₃C phase diagram.

5

(d) Discuss the cooling process of 0·6% C steel from 1,500 °C to room temperature.

5

8. (a) Give some applications of polyethylene, nylons and polyester.

4

(b) What is polymerisation ? With the help of suitable examples, compare and contrast the processes of addition polymerisation and condensation polymerization.

6

(c) Name two commonly used thermosetting polymers and their applications.

5

(d) Why are fiber glass reinforced composites used extensively ?

5

Group C

9. Answer the following questions :

2 × 10

(a) What is Bergers vector ?

(b) State Fick's second law of diffusion.

(c) Differentiate between interstitial and vacancy diffusion.

(d) What is work hardening ?

(e) Explain the reason for cracking of brass.

(f) How is martensite formed in steel ?

(g) If you subject a refractory lining to thermal gradient (heating at one end and cooling at other), how will high or low coefficient of thermal expansion and thermal conductivity affect its longevity ?

(h) Give two examples of soft magnetic materials.

(i) How do you determine the temperature for hot working of a metal ?

(j) Give two applications of nano materials.