RS

S'05 : 1 AN : AN 202/AD 302 (02)

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 supplemented 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*) What is a Burger vector? Show it by drawing a Burger circuit? What is Frank-Read source? State its importance in plastic deformation. 2+2+2

(*b*) Distinguish between: (2 × 2) + (2 × 2)

(*i*) Slip and Cross slip

(*ii*) Sessile dislocation and Glissile dislocation.

(*c*) What is Critical Resolved Shear Stress? Derive its formulae. 2+2

(Turn Over)

(*d*) Calculate the degree of freedom of ice and water kept in a beaker at 1 atmosphere pressure. 2

2. (*a*) State Fick's laws of Diffusion.

How can it help you in the problems of Case Carburising?

Given an activation energy, Q of 142 kJ/mol, for the diffusion of carbon in FCC iron and an initial temperature of 1000 K, find the temperature that will increase the diffusion coefficient by a factor 10. [$R = 8{\cdot}314$ J/(mol.K)].

Will you use a very high temperature? 2+2+(3+1)

(*b*) What is a Phase? What is the difference between α-iron and ferrite? Define an invariant reaction with an example. 2+2

(*c*) Differentiate between: (2×2)+(2×2)

(*i*) Phase Rule and Phase Diagram,

(*ii*) Solvus Line and Solidus Line.

3. (*a*) Explain Lever Rule with a Tie Line.

Find the weight percentage of pro-eutectoid ferrite just above the eutectoid temperature of a 0·3% C–steel. 2+2

(*b*) Derive the relationship between True Strain and Engineering Strain. What is Resilience? Why is it important for spring material? 2+(1+1)

(*c*) Describe Yield Point Phenomenon. Draw the engineering stress-strain diagram of Glass. Why does necking occur during tension test of a ductile material? 2+2+2

(*d*) Justify: 2×3

(*i*) Zinc is not as ductile as copper

(*ii*) Cold working increases hardness of materials

(*iii*) Steel is a brittle material at sub-zero atmosphere.

4. (*a*) Suggest one suitable material for each of the following purpose with justifications: 2×5

(*i*) File Cabinet

(*ii*) Water Tap

(*iii*) Manhole Cover

(*iv*) Garden Chair

(*v*) Glass Cutter.

(*b*) Explain with reasons: 2×5

(*i*) Ceramics are very hard

(*ii*) Solar cells are semiconductors with *p-n* junctions

(*iii*) High temperature creep is a diffusion controlled process

(*iv*) Brittle fracture commonly occurs in Grey Cast Iron

(*v*) Brass is always stronger than copper at room temperature.

Group B

5. (*a*) (*i*) Why has ferrite very low solubility of carbon, while austenite has high solubility of carbon? 2

(*ii*) What is Hardenability? Why is it not so high in plain carbon steels? 2+2

(*iii*) Draw the Peritectic reaction of Fe-C system. 2

(*b*) (*i*) State the advantages of Normalising over Annealing. 2

(*ii*) What is Critical Cooling Rate? Why is the shape of the T-T-T diagram in form of English letter 'C'? 2+2

(*iii*) What is Tempering? Is it essential for high carbon steel after quenching? 2

(*iv*) Write the scientific names of following polymers with one of their typical use: Teflon, ABS. 2×2

6. (*a*) Explain a Chain Polymerisation reaction. What is the Degree of Polymerisation?

If a particular type of polyethylene has a molecular mass of 140,000 g/mol, what is its degree of polymerisation? 2+2+2

(*b*) Distinguish between Homopolymer and Copolymer. 2×2

State the basic structural units of PMMA and Nylon 6, 6, elaborating their properties. (2×2)+(2×1)

(*c*) Define a Semiconductor and a Transistor. 2+2

7. (*a*) Differentiate between Ceramics and Glass, with examples.

What is the Glass Transition Temperature? What type of glass is used in spectacle lenses? (2×2)+2

(*b*) Explain the reasons for the rising popularity of Pure Oxide Ceramics over traditional refractories.

What is Magcarb? Where is it commonly being used? 2+2

(*c*) Draw the crystallographic unit of SiO_4^{4-} ion. What is Mullite? Explain Slip Casting. 2+(2+2)

(*d*) What is Alnico? Explain Patenting. 2+2

8. (*a*) (*i*) Why are monovalent metals like Silver or Copper so conductive? 2

(*ii*) Discuss Dielectric Constant and Dielectric Strength for ceramics. 2+2

(*iii*) Name two important ceramic insulators with their properties. 2

(*b*) (*i*) What is Hysteresis Loop? Explain its importance.

(*ii*) Distinguish between Diamagnetism and Paramagnetism. (2+2)+2

(*c*) What is E-glass? Where is it commonly used? 2+2

(*d*) By Energy Band Model explain the electrical conduction of an Intrinsic Semiconductor. 2

Group C

9. Answer the following: 2×10

(*i*) A tension test recorded an engineering strain of 0·0046 against the engineering stress of 345 MPa of a material within its elastic range. Find out the elastic modulus of the material and the type of metallic alloy (like ironbase, copperbase etc.)

(*ii*) The final thickness of a hard copper sheet is 1·0 mm. It was produced by cold working with 25% deformation. What was the starting thickness of the metal before cold working? To decrease the hardness what will you do?

(*iii*) Atomic radii of two metal atoms are 0·128 nm and 0·133 nm respectively. Find out whether they form an solid solution, and if they form, state what type of solid solution it is.

(*iv*) Write down the Slip Plane and Slip Direction (one plane and one direction only) of Nickel (only Miller indices). How many slip systems are there in Nickel?

(*v*) Brass has a peritectic reaction at a temperature of 903 °C, with 36·8% Zn (β–phase) in the middle and 32·5% Zn at α–phase end and 37·5% Zn at liquidus end. Find out the percentages of liquid phase and α–phase present at the peritectic point.

(*vi*) Calculate the degree of freedom for eutectic reaction for an iron-carbon alloy and an iron-cromium-nickel alloy, under 1 atmosphere.

(*vii*) State the crystal structures of Cementite and Martensite.

(*viii*) The fracture toughness equation of a material is given by $K_{Ic} = \sigma_f \sqrt{\pi . a}$. If the material has a strength of 300 MPa, and a fracture toughness of 4 MPa$\sqrt{m}$, find out the largest internal crack in microns the material will support without cracking. σ_f = strength MPa, a = Crack size, m.

(*ix*) Name two soft magnetic materials.

(*x*) Write the scientific names of PET and Melamine.