

**Code : 021305**

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**B.Tech 3rd Semester Exam., 2017**

**MATERIAL SCIENCE**

Time : 3 hours

Full Marks : 70

**Instructions :**

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.

1. Choose the correct answer (any seven) :

2×7=14

- (a) Which of the following is strong and ductile materials?
  - (i) Polymers
  - (ii) Ceramics
  - (iii) Metals
  - (iv) Semiconductors
- (b) Which of the following statements is false?
  - (i) Line defects are thermodynamically stable
  - (ii) Dislocation can end inside a crystal without forming loop
  - (iii) ABC ABC ABC ... is stacking sequence for HCP crystal
  - (iv) All of the above

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(c) Time-dependent permanent deformation is called

- (i) plastic deformation
- (ii) elastic deformation
- (iii) creep
- (iv) Anelastic deformation

(d) The most influencing factor of diffusivity is

- (i) diffusing species
- (ii) temperature
- (iii) lattice structure
- (iv) presence of defects

(e) Which of the following is not a Hume-Ruthery condition?

- (i) Crystal structure of each element of solid solution must be the same
- (ii) Size of atoms of each two elements must not differ by more than 15%
- (iii) Elements should form compounds with each other
- (iv) Elements should have the same valence

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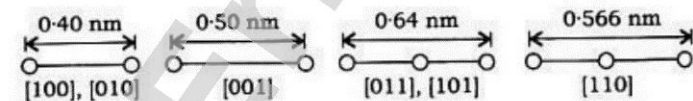
- (f) Phase formed of diffusionless reaction is
- pearlite
  - lower bainite
  - upper bainite
  - martensite
- (g) Eutectoid product in Fe-C system is called
- pearlite
  - bainite
  - ledeburite
  - spheroidite
- (h) Failure due to excessive deformation is controlled by
- material properties
  - design and dimensions
  - Both (i) and (ii)
  - None of the above
- (i) Most often machine components are failed by
- buckling
  - creep
  - fatigue
  - All of the above

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- (j) Last constituent to fail in fiber reinforced composites is
- matrix
  - fiber
  - Both fails at same time
  - Can't define

2. (a) The accompanying figure shows the atomic packing schemes for several different crystallographic directions for a hypothetical metal. For each direction, the circles represent only the atoms contained within a unit cell, the circles are reduced from their actual size. Draw the unit cell and identify the crystal structure :



- (b) Show that a line of dislocation contains edge, screw or mixed dislocations.
3. (a) For aluminium (atomic radius 0.1431 nm), compute the inter-planer spacing for (110) set of planes.
- (b) Calculate the atomic packing fraction for diamond cubic crystal and find its density (atomic radius  $r = 0.77 \text{ \AA}$ ).

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4. Construct and label different regions of Ag-Cu phase diagram using the following data :

Melting point of Ag = 960 °C

Melting point of Cu = 1085 °C

At eutectic point = 780 °C, eutectic composition = 28 wt% Cu, maximum solubility of Ag in Cu = 8 wt%, maximum solubility of Cu in Ag = 6 wt%

At room temperature, maximum solubility of Ag in Cu = 3 wt% and maximum solubility of Cu in Ag = 2 wt%

Assume the liquids, solidus and solvus line are straight. Calculate the amount of proeutectic phase in 60 wt% Cu alloy at 779 °C and draw the change in microstructures when cooled slowly from liquid state to room temperature.  $6+2+6=14$

5. Construct isothermal transformation diagram for eutectoid steel, determine and draw the final microstructure of a small specimen that has been subjected to the following time-temperature treatment. In each case, assume that the specimen begins at 800 °C, and that it has been held

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at this temperature long enough to have achieved a complete and homogeneous austenite structure :  $6+(2 \times 4)=14$

- (a) Rapidly cool to 250 °C, hold for  $10^5$  s, then quench to room temperature
  - (b) Rapidly cool to 400 °C, hold for 10 s, then quench to room temperature
  - (c) Rapidly cool to 700 °C, hold for  $10^5$  s, then quench to room temperature
  - (d) Rapidly cool to 650 °C, hold at this temperature for 6 s, rapidly cool to 400 °C, hold for 10 s, then quench to room temperature
6. For a polymer-matrix fiber-reinforced composite—
- (a) list three functions of the matrix phase; 6
  - (b) compare the desired mechanical characteristics of matrix and fiber phases; 4
  - (c) cite two reasons why there must be a strong bond between fiber and matrix at their interface. 4

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7. A continuous and aligned glass fiber-reinforced composite consists of 30 vol% of glass fibers having a modulus of elasticity of 69 GPa and 70 vol% of a polyester resin that, when hardened, displays a modulus of 3.4 GPa.

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

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(b) If the cross-sectional area is 250 mm<sup>2</sup> and a stress of 40 MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases.

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(c) Determine the strain that is sustained by each phase when the stress in part (b) is applied.

6

8. (a) What is cast iron? How does it differ from pig iron?

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(b) Compare ductile (nodular) cast iron with other cast iron on the basis of mechanical properties, composition and microstructure.

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9. Write short notes on the following :

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(a) Composite and alloys

(b) Annealing and normalizing

(c) Cross-slip and jog

(d) Frank-Read source

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