

**MATERIAL SCIENCE & ENGINEERING  
(CHEN 3133)**

**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)**

- Choose the correct alternative for the following: **10 × 1 = 10**
  - Diamond, an allotrope of carbon having covalent bonding between the carbon atoms is a \_\_\_\_\_ material  
(a) crystalline (b) semi-crystalline  
(c) amorphous (d) metallic.
  - Dislocations in solids are caused due to  
(a) point defects (b) surface defects  
(c) line defects (d) volume defects.
  - For rhombohedral crystal structure, the relation between the lattice constants a, b, c and angle  $\alpha, \beta, \gamma$  is  
(a)  $a = b = c$  and  $\alpha = \beta = \gamma \neq 90^\circ$   
(b)  $a \neq b \neq c$  and  $\alpha = \beta = \gamma = 90^\circ$   
(c)  $a = b \neq c$  and  $\alpha = \beta = 90^\circ, \gamma = 120^\circ$   
(d)  $a = b = c$  and  $\alpha = \beta = \gamma = 90^\circ$ .
  - The miller indices of a set of parallel planes which make intercepts in the ratio of 2a : 3b on the x and y axes and parallel to the z axis and a, b, c being the primitive vectors of the lattice are  
(a) (2 3 0) (b) (0 3 2) (c) (320) (d) (3 0 4).
  - A cation vacancy and an anion vacancy in a crystal of the type AB is called  
(a) Schottky defect (b) Frenkel defect  
(c) pair of vacancies (d) none of these.
  - What is the effective number of lattice points per unit cell of an FCC crystal?  
(a) 1 (b) 2 (c) 3 (d) 4.
  - The toughness of a material is tested by  
(a) tensile strength test (b) hardness test  
(c) creep test (d) impact test

- Fatigue failures of engineering materials occur due to the  
(a) compressive stress (b) tensile stress  
(c) cyclic stress (d) shear stress.
- Thermal difference between calcinations and roasting is  
(a) Calcination is done in excess of oxygen and roasting is done in limited oxygen  
(b) Roasting is done in excess of oxygen and Calcination is done in limited oxygen  
(c) Calcination is done in excess and roasting is done in absence of oxygen  
(d) Calcination is used in oxide ores and roasting is done in sulphide ores.
- Flux is added to ore in the smelting operation to  
(a) increase melting point of slag  
(b) increase melting point of gangues  
(c) decrease melting point of slag  
(d) decrease melting point of ore.

**Group - B**

- Define crystalline and non-crystalline materials with examples and mention the different crystal systems with their usual characteristic lattice parameters for a unit a cell (drawing of figures is not necessary).
  - Describe the relationship expressing the interplanar spacing ( $d_{hkl}$ ) as a function of the Miller's indices (hkl) and the lattice parameter 'a'.
  - Graphite & Diamond both are allotropes of carbon. Graphite conducts electricity but diamond does not. Explain. **(2 + 3) + 3 + 3 = 12**
- What do you understand by the term Miller indices of a crystal plane? Narrate the systematic procedure for the determination of Miller indices of a crystal plane.
  - Derive Bragg's equation for the determination of Crystal structure by X- ray diffraction.
  - If the 1<sup>st</sup> reflection from an FCC crystal has Bragg angle 21.5°. Find the value of Bragg angle for the 2<sup>nd</sup> reflection. **(3 + 2) + 4 + 3 = 12**

**Group - C**

- How would you classify crystal imperfections? Define Burgers vector with reference to edge dislocation and skew dislocations.

- (b) Derive an expression for the equilibrium concentration of defects with the enthalpy of formation of such defects in a crystal.
- (c) Find the equilibrium concentration of vacancies in Copper at 0 K, 300 K and 900 K considering enthalpy of formation of vacancies ( $\Delta H_f$ ) = 120 kJ/mol.
- (2 + 4) + 3 + 3 = 12**

5. (a) How are the hardness and toughness of materials measured?
- (b) Define plastic deformation and strain hardening. Explain the mechanism of slip.
- (c) Describe Kelvin-Voigt model for viscoelastic behaviour of materials.
- 4 + 4 + 4 = 12**

**Group - D**

6. (a) What do you understand by creep of a material. Show graphically and explain with reasons for various types of creeps that occur in a material?
- (b) Derive an expression for the equilibrium concentration of defects with the enthalpy of formation of such defects in a crystal.
- (c) Define plastic deformation and strain hardening. Explain the mechanism of slip.
- 4 + 4 + 4 = 12**

7. (a) What are eutectic and peritectic temperature in the phase transformations? Demonstrate the behaviour of different materials during deformation with the help of a stress-strain graph.
- (b) What are the Different heat treatment processes? State Gibbs Phase Rule with examples of binary & ternary phase diagrams.
- 2 + 4 + 6 = 12**

**Group - E**

8. (a) Differentiate between hydrometallurgy and pyrometallurgy. Show the steps in the Electrometallurgical process of extraction of aluminium.
- (b) Describe the industrial process of refining copper?
- (4 + 3) + 5 = 12**
9. (a) Differentiate between hot and cold working of metals.
- (b) Draw a neat diagram of a Blast furnace with appropriate temperature profile and feed & product flow & slag outlet for manufacturing iron.
- 6 + 6 = 12**