

**MATERIALS 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)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) For hexagonal crystal structure, the relation between the lattice constants a, b, c and angles α , β & γ is
 (a) $a = b = c$ and $\alpha = \beta = \gamma = 90^\circ$ (b) $a = b = c$ and $\alpha = \beta = \gamma \neq 90^\circ$
 (c) $a = b \neq c$ and $\alpha = \beta = 90^\circ, \gamma = 120^\circ$ (d) $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$
- (ii) Packing efficiency of a crystal depends on
 (a) Nature of bonding (b) Coordination number
 (c) crystal system (d) Valency.
- (iii) Time dependent recoverable deformation is called
 (a) elastic deformation (b) plastic deformation
 (c) anelastic deformation (c) permanent deformation.
- (iv) The miller indices of a set of parallel planes which make intercepts in the ratio of 3a:4b 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 1) (b) (0 3 4)
 (c) (4 3 0) (d) (3 0 4).
- (v) The toughness of a material is tested by
 (a) Tensile strength test (c) Creep test
 (b) Hardness test (d) Impact test.
- (vi) If the first reflection from an FCC crystal has a Bragg angle 21.5° , the 2nd reflection will have the angle
 (a) 18.5° (b) 25°
 (c) 31.2° (d) 36.8° .
- (vii) Fatigue failures of engineering materials occur due to the
 (a) Compressive stress (c) Cyclic stress
 (b) Tensile stress (d) Shear stress.

- (viii) Dislocations are called
 (a) Point imperfection (b) Line imperfection
 (c) Surface imperfection (d) Volume imperfection.
- (ix) 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.
- (x) Which of the following is not present in iron-iron carbide phase diagram?
 (a) α -ferrite (b) austenite
 (c) cementite (d) martensite.

Group - B

2. (a) How X-ray diffraction is performed on a powdered crystalline material? Give schematic presentation of powder diffractometer.
 (b) Derive an expression for interplanar spacing (d_{hkl}) as a function of the Miller's indices (hkl) and the lattice parameter 'a' of crystal.
 (c) A powder diffraction photograph of KCl gave us the following distances of 13.2, 18.4, 22.3, 26.2, 29.4, 32.2, 37.2, 39.6, 41.8, 43.8, and 46.0 mm from the centre spot where M_{α} X-rays of $\lambda = 70.8$ picometer were used in a camera of radius 57.4 mm. Index the lines to calculate h, k, l values. Determine the size of the unit cell and density of KCl.

4 + 4 + 4 = 12

3. (a) An orthorhombic unit cell has the following parameters a = 50 pm, b = 100 pm and c = 150 pm. What is the spacing of [12 3] planes?
 (b) What are the two different types of voids present in common crystals and calculate total number of octahedral voids present per unit cell of a FCC crystal.
 (c) Draw the planes with Miller's indices (110) & ($\bar{1} \bar{1} 1$) inside a cubic unit cell. Indicate the directions of the set of planes.

5 + 5 + 2 = 12

Group - C

4. (a) What are the different types of dislocation found in crystals? Narrate the difference between screw and edge dislocations with the help of Burger's vector circuit.
 (b) Derive an expression for the equilibrium concentration of Frenkel defects with the help of enthalpy of formation of such defects in the crystal.

(2 + 3) + 7 = 12

5. (a) State Gibbs Phase Rule with examples of binary and ternary phase diagrams.
- (b) Draw and explain the iron-carbon phase diagram showing different phase fields.
- (c) Explain T-T-T diagram for an eutectoid steel.

$$3 + 5 + 4 = 12$$

Group - D

6. (a) Describe the basic principle and process of steel making using LDAC converter.
- (b) Summarise the essential activities in a steel melting shop.
- (c) What is the purpose of vacuum treatment of molten steel?

$$6 + 3 + 3 = 12$$

7. (a) Why is smelting required during extraction of metals? What are the differences between reduction smelting and metallurgical metallothermic smelting? Discuss the reduction smelting of iron ore?
- (b) What is pyrometallurgical process of metal extraction? Discuss the principles and methods of continuous casting.

$$6 + 6 = 12$$

Group - E

8. (a) What are the essential features of hydrometallurgical process? Under what conditions it would be preferred to pyrometallurgical process?
- (b) Describe with a flow sheet the extraction alumina by Bayer Process indicating various factors involved. Explain the chemistry underlying the electrolytic production of aluminium.

$$4 + 8 = 12$$

9. (a) Describe KROLL's process for extraction of titanium metal by reduction of $TiCl_4$.
- (b) Depict the principle for the extraction of gold by cyanidation process followed by gold recovery through cementation process.
- (c) What is the purpose of zone refining?

$$4 + 6 + 2 = 12$$