

MATERIAL SCIENCE
(CHEN 2204)

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) Wridemann-Franz ratio is given by _____, where, k_B : Boltzmann constant; e : Electronic charge; n : Charge number.
(a) $\frac{\pi^2}{3} \left(\frac{k_B}{e} \right)^2$ (b) $\frac{\pi^2}{3} \left(\frac{e}{k_B} \right)^2$ (c) $\frac{\pi^2}{3} \left(\frac{k_B}{ne} \right)^2$ (d) $\frac{\pi^2}{3} \left(\frac{ne}{k_B} \right)^2$
- (ii) For a lattice plane of coordinate (0,-a,a/2) the Miller indices are given by _____, where 'a' is the lattice parameter.
(a) [0 2 1] (b) [0 $\bar{2}$ 1] (c) [0 2 $\bar{1}$] (d) [0 1 2]
- (iii) According to Hume-Rothery rule, atomic radii difference between impurity and replaceable atom must be less than about _____ for no defects generation.
(a) 5% (b) 10% (c) 15% (d) 20%
- (iv) Defect in CaCl_2 crystal on the accommodation of an ionic element is known as ____
(a) Frenkel effect (b) Schottkey effect (c) Stacking fault (d) Linear defect.
- (v) The burger vector for a slip plane {111} with a slip direction <110> can be given by _____, where, 'a' is the lattice parameter.
(a) $(a/2)\langle 110 \rangle$ (b) $(a/2)\langle 111 \rangle$ (c) $(a/2)\langle 101 \rangle$ (d) either (a) or (c)
- (vi) The percentage of carbon content in steel is _____
(a) 0.1 to 2 (b) 4 to 6 (c) 2 to 4 (d) 0.001 to 0.1.
- (vii) Leaching is a unit operation under _____
(a) Pyrometallurgy (b) Hydrometallurgy
(c) Electrometallurgy (d) Powder metallurgy.
- (viii) Predominance area diagram determines _____
(a) partial pressure of oxygen at which a metal oxide reduced to metal
(b) partial pressure of sulfur dioxide at which a metal sulphide can be reduced to metal
(c) stable form of any metal compound at a specific % of SO_2 & O_2
(d) all of above.

- (ix) Quartz and other gangue materials often act as catalysts during
(a) Roasting reaction (b) Calcination reaction
(c) Smelting reaction (d) Autocatalytic reaction
- (x) Flux is added to ore in the smelting operation to _____
(a) increase melting point of slag (b) decrease melting point of slag
(c) increase melting point of gangue (d) decrease melting point of ore.

Group- B

2. (a) What are the basic differences in metallic bond and ionic bond? Elaborate after citing example for each. [(CO1)(Remember/LOCQ)]
(b) Show that the atomic packing factor for a FCC crystal is 0.74. [(CO1)(Apply/IOCQ)]
(c) During XRD analysis of a substance the spectrum shows a peak at 120° attributing to [2 2 0] plane. If the lattice parameter is 0.3 nm, find out the interplanar distance. If one has doped impurity in the crystal that increases the interplanar distance, what will be the position of the peak for [2 2 0] plane in comparison to 120° ? [(CO1)(Evaluate/HOCQ)]
(2 + 2 + 1) + 3 + (2 + 2) = 12
3. (a) In case with the vacancy defect at 1000°C , the metal was analysed with 2.2×10^{25} number of vacancies per m^3 . Calculate the energy required to have this defect. Atomic weight: 63.5 g/mol; Atomic density: 8.4 g/cc and k: $8.62 \times 10^{-5} \text{ eV}/^\circ\text{C}$. [(CO1)(Evaluate/HOCQ)]
(b) With a 30% cold working condition, if 60 MPa tensile stress is applied on a cylindrical metal rod of length 0.1 m and diameter 0.1 m find out the modulus of resilience. The surface area got increased by 30% after applying the stress. [(CO2)(Evaluate/HOCQ)]
(c) What is the basic difference between recrystallization and growth during annealing treatment? [(CO1)(Remember/LOCQ)]
4 + 5 + 3 = 12

Group - C

4. (a) If the Superficial Rockwell hardness is indicated by HR15N, identify the amount of major load one can use for the hardness test. What is the difference between Brinell and Knoop hardness tests? [(CO2)(Remember/LOCQ)]
(b) "Atoms on the grain boundary are mostly taking part in conduction for semiconductors." – Justify the appropriateness of the statement with proper reasoning. [(CO2)(Analyse/IOCQ)]
(c) 60 MPa tensile stress is applied on the ferrite form of iron in $\langle 100 \rangle$ direction of a crystal lattice unit cell. Is there any slip happens for the plane {1 1 0} plane in $\langle \bar{1} 1 1 \rangle$ direction, when the maximum resolve stress is 30 MPa? [(CO2)(Evaluate/HOCQ)]
(1 + 2) + 3 + 6 = 12

5. (a) Draw the phase diagram for iron-carbon alloy with proper marking of the salient temperature and carbon composition during phase change. [[CO4](Remember/LOCQ)]
- (b) "Percentage cold working is a primary step to recreate a new grain structure at low process temperature." – Justify the appropriateness of the statement. [[CO2](Analyze/IOCQ)]
- (c) What is meant by magnetic domain wall? [[CO2](Remember/LOCQ)]
- 7 + 3 + 2 = 12**

Group - D

6. (a) Briefly discuss the different reaction zone of an Iron making blast furnace with the help of a neat diagram. [[CO3](Analyze/HOCQ)]
- (b) Briefly describe the continuous casting process of a curved mold machine with a help of a neat sketch. [[CO3, CO5](Remember/LOCQ)]
- 6 + 6 = 12**
7. (a) Explain the different reaction rate of Ni-S-O system at a constant temperature from a predominance diagram. [[CO3](Analyze/HOCQ)]
- (b) Differentiate between calcination and roasting. [[CO3](Understand/IOCQ)]
- (c) What is silicate degree? [[CO2](Remember/LOCQ)]
- 7 + 4 + 1 = 12**

Group - E

8. (a) Write a short note on electrorefining process. [[CO5](Remember/LOCQ)]
- (b) Explain the leaching kinetics of sulphide ores. [[CO5](Analyze/HOCQ)]
- (c) Define degree of dissolution. [[CO5](Understand/IOCQ)]
- 4 + 6 + 2 = 12**
9. (a) Briefly discuss the Hall-Heroult process of aluminium extraction from alumina with a help of a neat sketch. [[CO5] (Analyze/IOCQ)]
- (b) Draw a block diagram of conventional route of copper extraction from sulphide ores. [[CO5] (Remember/LOCQ)]
- 6 + 6 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.5	21.9	39.6

Course Outcome (CO):

After the completion of the course students will be able to

1. Understand structure of various materials and inherent defects.
2. Identify the mechanical, electronic and optical properties of various materials
3. Classify different metal extraction processes from their ores.
4. Analyze solid and liquid phase behavior from phase equilibrium study.
5. Explain the process flow in the manufacturing/extraction of relevant metal/alloy.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question;
HOCQ: Higher Order Cognitive Question