MATERIAL SCIENCE
(CHEN 3102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Madelung constant for sodium chloride (NaCl) crystal is _____.
(a) 1.747 (b) 1.386 (c) 1.332 (d) 1.799

(ii) Steady state deformation rate at a particular temperature (T) under constant stress (σ) in a creep curve can be written as _____, where Q is activation energy and c,n are constants.
(a) $c(\sigma)^{\frac{1}{n}}\exp\left(-\frac{Q}{RT}\right)$ (b) $c\sigma\exp\left(-\frac{Q}{RT}\right)$
(c) $c(\sigma)^{n}\exp\left(-\frac{Q}{RT}\right)$ (d) $c\left(\frac{1}{\sigma}\right)^{\frac{1}{n}}\exp\left(-\frac{Q}{RT}\right)$

(iii) During fracture toughness calculation the 'Y' value for edge crack of solid material of infinite thickness is equal to _____.
(a) 1.0 (b) 1.1 (c) 1.2 (d) 1.5

(iv) Maximum solubility of carbon in austenite is _____.
(a) 0.1 to 2 (b) 4 to 6 (c) 2 to 4 (d) 0.001 to 0.1

(v) Stress concentration factor is given by the _____ maximum stress and nominal tensile stress.
(a) difference between (b) summation of
(c) multiplication of (d) ratio between

(vi) Choose the correct order of reducing agent _____.
(a) Cu>Fe>Zn>Al>Mg (b) Fe>Zn>Cu>Mg>Al
(c) Mg>Al>Zn>Fe>Cu (d) Al>Mg>Cu>Fe>Zn

(vii) Rapid degassing occurs due to _____.
(a) Sudden exposure of molten stream in vacuum
(b) Slow exposure of molten stream in vacuum
(c) Sudden exposure of molten stream in water
(d) Slow exposure of molten stream in water

(viii) Anode slime contains _____.
(a) impurities in blister copper (b) precious metal
(c) copper sulphate and sulphuric acid (d) alcohol

(ix) Which factors influence the viability of a leaching operation?
(a) The degree of dissolution (b) The selectivity of the leaching reaction
(c) The cost of the leach solution (d) All of these.

(x) Which is used as electrolyte in Aluminium extraction _____.
(a) Cryolite (b) Aluminium fluoride
(c) Lithium fluoride (d) Both (a) and (b)

Fill in the blanks with the correct word

(xi) Physical changes occur in pyrometallurgy at high temperature of _____.

(xii) In case with a stacking fault within a FCC crystal …ABCABCABC…. with the twin boundary at A and B are initiated after non-lattice translation of 'C' layer _____ times of $\frac{1}{6}\{\bar{2}\ 1\ 1\}$.

(xiii) _____ is commercially the most important ore of copper extraction.

(xiv) The binding energy of Lithium per gram of atom is _____ kJ for the metal lattice.

(xv) The bond angle within H_2O is equal to _____.

Group - B

2. (a) FESEM analysis is done for MS to understand the grain boundary and the image taken for analysis is with 100x magnification. During analysis 5 grains are taken through which a line is drawn with a scale 10 μm. Find out the average grain size. *[(CO1)(Analyse/HOCQ)]*

(b) What is the difference between small angle and large angle grain boundary? Elaborate with a proper schematic. *[(CO1)(Remember/LOCQ)]*

(c) For a FCC crystal show that the two slip vectors <0 $\bar{1}$ 1>and <1 0 $\bar{1}$ >for an edge dislocation annihilates, while <0 $\bar{1}$ 1> and <1 $\bar{1}$ 0> do not (draw neat schematic for the slip planes considered). *[(CO1)(Apply/IOCQ)]*

3 + (2 + 2) + 5 = 12

3. (a) Show that the packing factor for Hexagonal Closed Packing (HCP) is 0.74. *[(CO1)(Analyse/HOCQ)]*

(b) "FCC crystals show more plastic deformation compared to BCC crystals although FCC has less slip systems compared to BCC." – Justify the appropriateness of the statement. *[(CO1)(Apply/IOCQ)]*

(c) Bond energy for H_2 is 430 kJ/mol and for Cl_2 is 238 kJ/mol. Calculate the bond energy for HCl formed through reaction between H_2 and Cl_2. If the actual bond energy is 426 kJ/mol, calculate the ionic contribution. *[(CO1)(Analyse/HOCQ)]*

5 + 4 + 3 = 12

Group - C

4. (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. *[(CO1)(Apply/IOCQ)]*

   (c) What is meant by magnetic domain wall? *[(CO2)(Remember/LOCQ)]*

7 + 3 + 2 = 12

5. (a) "After recrystallization at elevated temperature a material A becomes opaque even when the material is transparent at the beginning of the experiment." – Comment on the correctness of the experiment and narrate your analysis on it. E_g for the material is 5eV. *[(CO2)(Apply/IOCQ)]*

   (b) What is meant by conduction and valence band? Elaborate the variation of band energy with the lattice parameter at the time 2s and 2p orbital overlapping using a neat energy diagram. *[(CO2)(Remember/LOCQ)]*

   (c) What is meant by extrinsic semiconductor and how the N-type semiconductor is going to be designed? *[(CO2)(Remember/LOCQ)]*

4 + (2 + 3) + 3 = 12

Group - D

6. (a) Discuss the limitation of Ellingham diagram. *[(CO3)(Apply/IOCQ)]*

   (b) Explain the operating principle of fluo-solid roasting with the help of diagram. *[(CO3)(Remember/LOCQ)]*

   (c) What is smelting? *[(CO3)(Remember/LOCQ)]*

3 + 6 + 3 = 12

7. Discuss the thermodynamics behaviour of Ni-S-O roasting reaction with the help of a diagram. *[(CO3)(Analyse/HOCQ)]*

12

Group - E

8. (a) Explain the electrorefining process. *[(CO3)(Analyse/IOCQ)]*

   (b) Explain the leaching kinetics of sulphide ore. *[(CO3)(Understand/IOCQ)]*

   (c) Define the degree of dissolution. *[(CO3)(Remember/LOCQ)]*

4 + 6 + 2 = 12

9. (a) Draw the block diagram of hydrometallurgical extraction of low grade of copper. *[(CO4)(Remember/LOCQ)]*

   (b) Briefly discuss the Hall-Heroult process of aluminium extraction. *[(CO4)(Understand/IOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.58	36.45	23.96