



Name : .....  
Roll No. : .....  
Invigilator's Signature : .....

**CS/B.TECH(CT)/SEM-6/MS(CT)-601/2012**

**2012**

**ENGINEERING MATERIAL SCIENCE**

Time Allotted : 3 Hours

Full Marks : 70

*The figures in the margin indicate full marks.*

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

**GROUP - A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for the following :  $10 \times 1 = 10$

i) Layered silicate sheet structures in clays consists of  
which of the following groups ?

- a)  $\text{SiO}_4^{4-}$                       b)  $\text{Si}_2\text{O}_5^{2-}$   
c)  $\text{Si}_2\text{O}_7^{6-}$                       d)  $\text{SiO}_3^{2-}$ .

ii) Typical density of dislocation in a solid

- a)  $10^8 - 10^{10} \text{ m}^{-2}$               b)  $10^8 - 10^{10} \text{ cm}^{-2}$   
c)  $10^8 - 10^{10} \text{ mm}^{-2}$             d)  $10^8 - 10^{10} \mu\text{m}^{-2}$ .



- iii) Plastic deformation results from which of the following ?
- a) slip
  - b) twinning
  - c) viscoelasticity
  - d) both (a) and (b)
  - e) all of these.
- iv) In a single-component condensed system, if the degree of freedom is zero, maximum number of phases that can coexist is
- a) 0
  - b) 1
  - c) 2
  - d) 3
  - e) 4.
- v) Which of the following is not a Hume-Rothery condition ?
- a) Elements should have the same valence
  - b) Elements should form compounds with each other
  - c) Size of atoms of each two elements must not differ by more than 15%
  - d) Crystal structure of each element of solid solution must be the same.
- vi) Fracture surface appear to be fibrous in case of
- a) shear
  - b) cleavage
  - c) transgranular
  - d) intergranular.



- vii) If a surface crack causing fracture in a brittle material is halved, the fracture strength will
- a) decrease by a factor  $\sqrt{2}$
  - b) increase by a factor 2
  - c) decrease by a factor 2
  - d) increase by a factor  $\sqrt{2}$ .
- viii) Passivity is not reason for inertness of which of the following materials ?
- a) Au
  - b) Al
  - c) Ti
  - d) Ni.
- ix) Difficult to monitor and very dangerous form of corrosion
- a) galvanic
  - b) crevice
  - c) pitting
  - d) intergranular.
- x) Which among the following metals can be used for cathodic protection ?
- a) Zn
  - b) Ni
  - c) Al
  - d) Cu.

**GROUP - B**

**( Short Answer Type Questions )**

Answer any *three* of the following.  $3 \times 5 = 15$

2. State the factors responsible for the stress required to cause slip in a pure metal single crystal. Derive the relationship between a uniaxial stress acting on a cylinder of a pure metal single crystal and the resulting resolved shear stress on a slip system. 2 + 3



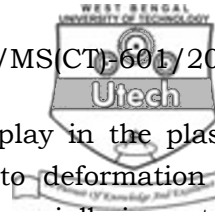
3. Enumerate the differences between slip and twinning deformation mechanisms of metals with sketches.
4. Discuss strengthening mechanism of metals by grain size reduction.
5. Narrate the fundamental postulates of Drude-Lorentz theory of metals. What are the conspicuous successes and failures of free electron theory ? 2 + 3
6. What is Pilling-Bedworth ratio ? Discuss catastrophic oxidation of metals and alloys. Which action can retard this behaviour in iron alloys ? 1 + 3 + 1

**GROUP - C**

**( Long Answer Type Questions )**

Answer any *three* of the following. 3 × 15 = 45

7. a) With the help of a time-independent form of Schrödinger's wave equation prove that the energy of an electron in a metal is quantised. 10  
 b) An electron in a cubical box of metal is subjected to the influence of a magnetic field such that its length  $l$  increases by  $dl$ , while its breadth  $b$  and thickness  $d$  remain unchanged. Show that the energy difference between the states (311) and (111) is  $\frac{h^2}{8ml^2} \left( \frac{16 dl}{1} \right)$ . 5
8. a) What is slip deformation ? Which ideas provide you the basis for the observation that slip occurs most readily in closed packed planes and closed packed directions only ? Which among FCC, BCC and HCP metals is most plastic and why ? 1 + 2 + 2  
 b) Prove that maximum shear stress at which slip occurs is  $\frac{G}{2\pi}$ , where  $G$  is the shear modulus. 6



- c) What important role does twinning play in the plastic deformation of metals with regard to deformation by slip ? Why is deformation twinning especially important for HCP metals ? In which condition twins are formed in FCC and BCC metals ? 1 + 1 + 2
9. a) Discuss the mechanism of solid solution hardening. Draw the nominal stress-strain curve for a solid solution hardened metal. How would it be different from that of mild steel or copper ? 4 + 1 + 1
- b) Explain the mechanism of work hardening of metals. Point out a major disadvantage of work hardening as a method of increasing strength of a metal or alloy. 4 + 1
- c) When a cold worked metal is heated into temperature range where recovery, recrystallization & grain growth take place, show schematically how are (i) internal residual stress, (ii) strength, (iii) hardness and (iv) ductility affected. 4
10. a) Prove that the theoretical cohesive strength of metals ranges between  $E/6$  to  $E/10$ , where  $E$  is the Young's modulus. 8
- b) Deduce and discuss quantitatively as to how failure becomes evident as a crack propagates in a material with reference to stress concentration at the crack tip. 4
- c) Fused silicon has a surface energy of  $4.23 \text{ J/m}^2$  and an elastic modulus of  $69,000 \text{ MPa}$ . A large plate of this material is to withstand a normal internal stress of  $35 \text{ MPa}$ . What is the largest flaw in mm that can be tolerated without fracture occurring ? 3



11. a) Define corrosion as it pertains to materials. State the factors that affect corrosion of metals. 2
- b) What is 'area effect' in respect of galvanic corrosion of metals ? Which of the following conditions is more favourable from a corrosion prevention standpoint
- i) large Cu plate, steel rivets
  - ii) large steel plate, copper rivets ? 4
- c) Consider a copper-zinc corrosion couple. If the current density at the Cu cathode is  $0.05 \text{ A/cm}^2$ , calculate the weight loss of Zn per hour if,
- i) the Cu area is  $100 \text{ cm}^2$ , Zn area is  $1 \text{ cm}^2$
  - ii) the Cu area is  $1 \text{ cm}^2$ , Zn area is  $100 \text{ cm}^2$ .
- Comment on the rate of corrosion in so far as anode area is concerned. ( Mol. wt. of Zn =  $65.35 \text{ gm/mol}$  ) 4
- d) On half of an electrochemical cell consists of a pure Ni electrode in a solution  $\text{Ni}^{2+}$  ions; the other half is Cd electrode immersed in a  $\text{Cd}^{2+}$  solution.
- i) If the cell is standard one, write the spontaneous overall reaction and calculate the voltage that is generated given that half cell potentials for Cd and Ni are respectively  $-0.403 \text{ V}$  and  $-0.250 \text{ V}$ .
  - ii) Compute the cell potential at  $25^\circ\text{C}$  when the  $\text{Cd}^{2+}$  and  $\text{Ni}^{2+}$  concentrations are  $0.5 \text{ M}$  and  $10^{-3} \text{ M}$  respectively.
- Is the spontaneous reaction direction still the same as for the standard cell and why ? 5



12. a) What are the important factors of consideration if a metal is to form a protective oxide ? 3
- b) Discuss the anion-cation diffusion mechanism of oxide formation on metals with relevant sketches. 4
- c) Using equations, describe the linear, parabolic & logarithmic oxidation of metals behaviour with examples. 5
- d) A  $1 \text{ cm}^2$  sample of 99.94 wt% nickel, 0.75 mm thick is oxidised in oxygen at 1 atm pressure at  $600^\circ\text{C}$ . After 2 hours, the sample showed a weight gain of  $70 \mu\text{g}/\text{cm}^2$ . If this material shows parabolic oxidation behaviour, what will the weight gain be after 10 hours ?

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