Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(CT)/SEM-6/MS(CT)-601/2010

2010

ENGINEERING MATERIALS 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 × 1 = 10

   i) Which is *not* a characteristic property of a ceramic material ?

      a) High temperature stability

      b) High mechanical strength

      c) Low elongation

      d) Low hardness.

   ii) Which of the following is/are false ?

      a) Line defects are thermodynamically stable

      b) Dislocations can end inside a crystal without forming loop

      c) ABC ABC ABC ... is stacking sequence for HCP crystal

      d) All of these.

iii) Burger's vector changes with

a) Kind of dislocation

b) length of dislocation

c) kind and length of dislocation

d) none of these.

iv) Repeatable entity of a crystal structure is known as

a) crystal b) lattice

c) unit cell d) Miller indices.

v) The atomic diameter of the element forming a B.C.C. crystal (if a is lattice parameter) is

a) a b) $\frac{a}{2}$

c) $\frac{a}{(4\sqrt{3})}$ d) $\frac{a}{(4\sqrt{2})}$.

vi) Higher the degree of deformation, recrystallization temperature is

a) higher b) lower

c) no effect d) either higher or lower.

vii) Which of the following equations is related to corrosion rate ?

a) Nernst equation b) Faraday's equation

c) Either (a) or (b) d) Neither (a) nor (b).

viii) The form of corrosion occurs due to concentration difference in a component is

a) uniform b) galvanic

c) inter-granular d) stress.

ix) If the surface crack causing fracture in a brittle material is made twice as deep, the fracture strength will

a) decrease by a factor of $\sqrt{2}$

b) decrease by a factor of 2

c) decrease by a factor of 2^2

d) no change.

x) Beneficial property of foreign particles

a) reduces density

b) act as stress raisers

c) obstructs dislocation motion

d) none of these.

GROUP – B

(Short Answer Type Questions)

Write short notes on any *three* of the following. 3 × 5 = 15

2. Activation and concentration polarization.

3. Cathodic protections of metals.

4. Primary and secondary recrystallization.

5. A comparative study of Slip and twinning.

6. Critical resolved shear stress for slip.

GROUP – C

(Long Answer Type Questions)

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

7. a) Assuming one dimensional periodic potential field, solve the Schrodinger's wave equation using 'Bloch function' and 'Kroning-Penney' models with necessary sketches and show how energy bands result from it.

   b) What are Brillouin zones ? State the condition for 'Bragg reflection' from a two dimensional square lattice with a sketch.

   c) Discuss 'Density of states' of electron giving mathematical expression. 8 + 3 + 4

8. a) Deduce a mathematical expression that would indicate the maximum stress to be applied for slip to occur in a perfect metallic lattice.

   b) Discuss with sketches how the movement of dislocation through a material produces a step at the free surface of a metal.

   c) Calculate the shear strain rate in terms of dislocation density in a crystal. 6 + 3 + 6

9. a) 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.

   b) Enumerate the different types of tensile fractures occuring in metals with sketches. What are transgranular and intergranular cleavage and shear fracture ?

   c) Calculate the surface energy in J/m^2 of a surface etched soda-lime-silica glass which has a fracture strength of 100 MN m^{-2} and a Young's modulus of 70 GN m^{-2}. It is assumed that etching has removed all the surface cracks and a number of cracks are present inside the glass sample varying in length from 1 μm to 5 μm. 6 + 5 + 4

10. a) What are the important factors of consideration if a metal is to form a protective oxide ?

    b) Discuss the anion-cation diffusion mechanisms of oxide formation on metals with relevant sketches.

    c) Calculate the ratio of the oxide volume to the metal volume for the oxidation of Aluminium to Aluminium oxide. The density of Aluminium = 2·70 g/cm^3 and that of Al_2O_3 = 3·70 g/cm^3.

    (At. wt. of Al = 26·98, At. wt. of oxygen = 15·9994)

    Comment on the result obtained.

    d) A sample of pure iron oxide is according to the linear oxidation law. After 5 hours at 720°C, a 1 cm^2 sample shows a weight gain of 9 $\mu g/cm^2$. How long an oxidation time will it take for the sample to show a weight gain of 35 $\mu g/cm^2$? 3 + 4 + 4 + 4

11. a) Draw the nominal stress-strain curve for mild steel and explain the principal features of it. Define true stress and true strain. How do the true stress-strain curve for the same would look like ?

    b) Discuss recovery, recrystallization and grain growth in respect of annealing of metals. How do they affect internal residual stress, strength, ductility and hardness of the material ?

    c) If it takes $9 \infty 10^3$ mins to recrystallize a piece of copper at 88°C and 200 mins at 135°C, what is the activation energy for the process assuming the process obeys the Arrhenius type rate equation and the time to recrystallize = $Ce^{+Q/RT}$ where, R = 8·314 J/(mol.K) and T is in Kelvin ? 6 + 6 + 3

12. a) Define corrosion as it pertains to materials. What are some of the factors that affect the corrosion of metals ?

b) One-half of an electrochemical cell consists of a pure nickel electrode in a solution of Ni^{2+} ions ; the other half is a cadmium electrode immersed in a Cd^{2+} solution.

i) If the cell is a standard one, write the spontaneous overall reaction and calculate the voltage that is generated.

ii) Compute the cell potential at 25°C if the Cd^{2+} and Ni^{2+} concentrations are 0·5 M and 10^{-3} M, respectively. Is the spontaneous reaction direction still the same as for the standard cell ?

(Half cell potentials for Cd and Ni are – 0·403 V and – 0·250 V respectively)

c) Consider a 0·95% carbon steel. In which condition is the steel more corrosion resistant ?

i) Martensitic

ii) Tempered martensitic in 200° - 500°C range.

d) A mild steel cylindrical tank 1 m high and 50 cm in diameter contains aerated water to the 60 cm level and shows a loss in weight due to corrosion of 304 g after 6 weeks.

Calculate the following :

i) The corrosion current

ii) The current density involved in the corrosion of the tank. Assume uniform corrosion on the tank's inner surface and that the steel corrodes in the same manner as pure iron.

(At. mass of Fe = 55·85 g/mol) 3 + 4 + 4 + 4