Total number of printed pages – 8

B. Tech

CPMT 6306

Sixth Semester Examination – 2008

PHASE TRANSFORMATION AND HEAT TREATMENT

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*
The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2 ×10

   (a) Why is an ideal solution always stable with respect to the pure components ?

   (b) Why is interstitial diffusion generally faster than substitutional diffusion ?

   (c) Compare the activation energy for diffusion in amorphous solids to that in crystalline solids.

   (d) Can a reaction occur spontaneously in the absence of an enthalpy change ? And if yes then explain under what condition it is possible ?

   (e) What is critical cooling rate ? And on what factors does the critical cooling rate of a steel depend ?

   (f) Differentiate between interface controlled growth and diffusion controlled growth.

   (g) Distinguish martensitic transformation from pearlitic transformation.

   (h) What are the different types of interphase interfaces in solids ?

   (i) What are the driving forces for recovery, recrystallization and grain growth processes in materials ?

   (j) Distinguish through suitable sketches between an annealed structure and a quenched and aged structure of an age hardenable alloy.

2. (a) Derive and explain with the help of a suitable diagram the Gibbs energy of formation, ΔG, of a localized fluctuation in a homogeneous binary phase. 5

(b) For a one dimensional non steady state diffusion couple problem, where two infinitely long bars of different but uniform solute concentrations are joined end to end, determine and show with the help of a suitable diagram the variation of the solute concentration C as a function of distance x from the interface and time t, when diffusion coefficient, D, is independent of concentration. 5

3. (a) Derive and compare the expressions for the Gibbs energy of formation of critical embryo and the rate of homogeneous nucleation of a spherical new phase particle, β, from the parent α phase with that of heterogeneous nucleation of β formed at impurity surfaces. 6

(b) Melting point and enthalpy of melting of tin are 232 °C and 0.42×10^9 J/m^3, respectively. Calculate the under-cooling required for liquid to solid transformation to start if appreciable nucleation occurs only when critical Gibbs energy of nucleation drops to about 1.5×10^{19} J. Solid / liquid interfacial energy is 0.055 J/m^2. 4

4. (a) In a Gibbs triangle show the ternary alloy represented by the point T having 60 wt % A, 20 wt % B and 20 wt % C. 2

(b) Three phases α, β and γ are in equilibrium with each other at a temperature T. The compositions of the three phases are,

α :	$X_A^{\alpha} = 0.6$	$X_B^{\alpha} = 0.2$	$X_C^{\alpha} = 0.2$
β :	$X_A^{\beta} = 0.2$	$X_B^{\beta} = 0.5$	$X_C^{\beta} = 0.3$
γ :	$X_A^{\gamma} = 0.3$	$X_B^{\gamma} = 0.1$	$X_C^{\gamma} = 0.6$

and the relative proportions are, $\alpha : \beta : \gamma = 0.3 : 0.3 : 0.4$. Determine the composition of the ternary alloy which dissociates into three phases α, β and γ at the temperature T. 3

(b) A ternary system A-B-C shows complete solubility of the components in the solid as well as in the liquid state.

(i) Draw the space model of the ternary system with $T_B > T_A > T_C$, where, T_A, T_B and T_C are the melting temperatures of A, B and C respectively. 2

(ii) Draw isothermal sections at T_1, T_A, and T_2 defined by $T_B > T_1 > T_A > T_2 > T_C$. 3

5. (a) In a binary eutectic system having terminal solid solutions draw the free energy composition diagrams of the phases at temperatures T_1, T_2, T_3, T_E and T_4. Where

T_A and T_B are melting temperatures of A and B, T_E is the eutectic temperature and $T_1 > T_A > T_2 > T_B > T_3 > T_E > T_4$. 4

(b) How is the recrystallization temperature of a material defined ? On what factors does the recrystallization temperature of a material depend ? 3

(c) Explain long range ordering in binary solutions and determine the long range order parameter, L, in an alloy. 3

6. (a) Draw and label the iron-cementite phase diagram and show the differences seen in the iron-graphite phase diagram. 4

(b) Explain the changes in microstructure that occur in a hypo eutectoid steel, a eutectoid steel and a hyper eutectoid steel when cooled slowly from the austenite region to room temperature. 3

(c) In an annealed steel having 30 wt% proeutecotid ferrite and 70% pearlite calculate the carbon content of the steel and the total ferrite and cementite present in the steel. 3

7. (a) Compare the microstructure and properties of an annealed and a normalized steel of the same composition. 3

(b) How do the alloying elements affect the hardenability of a steel ? 3

(c) Explain the changes in structure and properties during the different stages of tempering. 4

8. (a) Explain with the help of the TTT diagram the resulting microstructures and the properties of a eutectoid steel at different temperatures of transformation. 4

(b) Explain the different types of martensitic transformations based on the kinetic characteristics. 3

(c) Discuss the different types of morphologies of martensite and the conditions in which each type occurs. 3

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