BE / B Tech (Full Time) DEGREE END SEMESTER EXAMINATIONS NOV / DEC 2012 (24)

MATERIALS SCIENCE & ENGINEERING BRANCH

SEVENTH SEMESTER

ML-9022 – Physical Metallurgy of Ferrous and Aluminium Alloys

(REGULATIONS 2008)

Time : 3 hrs. Max. Mark : 100

Instructions : 1. Read questions carefully. Write 'to the point' answers

2. Draw neat sketches wherever necessary

Answer ALL Questions

Part – A (10 x 2 = 20 Marks)

1. State Fick's first law of diffusion.
2. What is 'random jump characteristics' of interstitial diffusion?
3. Define recrystallization temperature.
4. Name one ordered lattice and draw the corresponding lattice structure.
5. What is miscibility gap?
6. In case of precipitation in an Al – 4% Cu alloy system, transition phases form prior to the equilibrium phase. Why?
7. What is 'shape memory effect'?
8. What is known as 'site saturation'?
9. What is cellular transformation?
10. What is polygonization?

Part – B (5 x 16 = 80 Marks)

11. (a) What is 'free energy'? Derive the free energy of a system (per mole) before and after mixing its constituent elements A and B. In the process, calculate the change in entropy. Assume relevant parameters. Also draw the corresponding ΔG vs. composition curves. (8)

(b) Define ΔH (change in enthalpy of above system) in terms of bond energies. Discuss in detail the possible values of ΔH and corresponding changes in the system. (8)

12. (a) (i) Derive Avrami equation for a cellular transformation $\alpha \rightarrow \beta$ in which the product phase is continuously nucleated throughout the transformation process. Assume necessary parameters. (5)

(ii) Calculate the time required for 75% phase transformation if the system has a nucleation rate of 10^6 m^{-3} s^{-1} and subsequent growth rate of 1mm/s. (3)

(iii) Describe Bainitic transformation with respect to transformation mechanisms and kinetics, process and microstructures evolved. (8)

OR

(b) (i) Discuss in detail the 'Gibbs –Thomson' effect. (8)

(ii) Illustrate 'particle coarsening' focusing on its governing equation, thermodynamics and the factors affecting particle coarsening. (8)

13. (a) What is Martensitic transformation? With respect to martensitic transformations, explain the followings: (i) driving force for the transformation, (ii) microstructures of martensite, (iii) nucleation kinetics & role of dislocation in martensite nucleation. (1+15)

OR

(b) What is order-disorder transformation? With respect to order-disorder transformations, explain the followings: (i) thermodynamics of order-disorder transformation, (ii) ordering of 'β-brass', (iii) 1st and 2nd order transformations. (1+15)

14. (a) (i) Discuss in detail the growth of a pure solid on atomically rough and smooth surfaces.

(ii) For the growth of a newly formed solute B-rich β-precipitate (composition, C_β) from parent α-phase (bulk composition C_0 and equilibrium composition at the interface is C_e), show that the precipitate thickening obeys a parabolic growth law with time t, i.e., thickness of the slab, $x \propto \sqrt{(Dt)}$, D being the diffusivity of species B. Assume other relevant parameters. (8+8)

OR

(b) Discuss in detail: (i) Spinodal decomposition, (ii) Austenite to ferrite transformation. (8+8)

15. (a) (i) Write down the expression for the change in free energy for a homogeneous nucleation process and explain all the terms. In a plot of energy vs. radius of nucleus, show how these energy terms vary with the size of nucleus. (6)

(ii) From the above expression, determine the critical driving force and the critical size of the nucleus. (4)

(iii) A new phase forms in the shape of a disc of radius r and semi-thickness c. The misfit strain energy per unit volume is A(c/r). Determine the value of c for which the change in free energy for the nucleation of a given volume is a minimum. Assume γ is the interfacial energy per unit area. (6)

OR

(b) (i) Write down the general solution of Fick's second law for non-steady state diffusion. (2)

(ii) Draw a concentration vs. distance profile for the carburization of steel. (2)

(iii) At 900°C, what is the time required to carburize a steel with an initial composition of 0.2% carbon to 1% carbon at a depth of 0.2 mm? Assume a constant surface concentration of 1.4% carbon due to the carburizing atmosphere. Use: D_c in γ-Fe at 900°C $\approx 1.35 \times 10^{-11}$ m^2/s . (8)

(iv) Discuss how the corrosion resistance of duralumin is achieved based on the Fick's second law. (4)

TABLE 5.1 Tabulation of Error Function Values

z	erf(z)	z	erf(z)	z	erf(z)
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999