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B.E. / B.Tech. (Full Time) DEGREE ARREAR EXAMINATIONS, APRIL / MAY 2013  
MATERIALS SCIENCE AND ENGINEERING BRANCH  
SEVENTH SEMESTER – (REGULATIONS 2008)

**ML 9022 – PHYSICAL METALLURGY OF FERROUS AND ALUMINIUM ALLOYS**

Time : 3 hrs

Max Mark: 100

Answer ALL Questions

Part – A (10 x 2 = 20 Marks)

14

1. Define misfit strain.
2. What is non-steady state diffusion? Write the expression for Fick's 2<sup>nd</sup> law of diffusion?
3. What is heterogeneous nucleation?
4. In a TTT-diagram, draw a cooling curve which will yield 50% bainite and 50% martensite?
5. What is an anti-phase boundary (APB)?
6. For the martensitic transformation, write down the expression for  $\Delta G$  in terms of the martensite start temperature ( $M_s$ ), equilibrium temperature ( $T_0$ ) and the change in enthalpy ( $\Delta H$ ).
7. What is spinodal decomposition?
8. What are the steps involved in grain-boundary precipitation?
9. Write down the precipitation sequence in an Al – 4 wt% Cu alloy aged at 190°C.
10. What do you mean by Secondary recrystallisation?

Part – B (5 x 16 = 80 Marks)

11. (i) A liquid is cooled to a temperature  $T$ , below its melting point,  $T_m$ . Show that the driving force for solidification is proportional to the undercooling given to the system. Assume latent heat of melting/ solidification is  $L$ . (6)
- (ii) 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  $M(c/r)$ . Determine the value of  $c$  for which the change in free energy for the nucleation of a given volume is a minimum. Assume  $\gamma$  is the interfacial energy per unit area. (6)
- (iii) What are the effects of temperature and alloy composition on the nucleation rate? (4)
12. (a) (i) Name the various growth processes for metals and non-metals. (3)
- (ii) Illustrate with neat sketch the influence of interface undercooling ( $\Delta T$ ) on growth rate for atomically rough and smooth surfaces. (5)

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(iii) For the growth of a newly formed solute B-rich  $\beta$ -precipitate (composition,  $C_\beta$ ) from parent  $\alpha$ -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)

(OR)

12. b. (i) State the mechanism of vacancy diffusion. (3)  
(ii) What is the 'random jump characteristics' of interstitial diffusion? (3)  
(iii) For a dilute interstitial solid solution having concentration gradient with respect to solute B-atoms, show that the net flux of B-atoms, down the concentration gradient, obeys Fick's 1st law. Consider 'random jump characteristics' and assume relevant parameters. (10)

13. a. (i) Why is martensitic transformation called Diffusionless transformation? (4)  
(ii) With respect to martensitic transformations, explain the following : (i) driving force for the transformation, (ii) microstructures of martensite, (iii) nucleation kinetics & role of dislocation in martensite nucleation, (iv) Bain distortion model (12)

(OR)

13.b. What is a Shape memory effect? Discuss in detail about the examples and applications of Shape memory alloys.

14. a. (i) What is Gibbs-Thomson effect? (3)  
(ii) Derive the expression for  $\Delta G$  based on Gibbs-Thomson effect. (6)  
(iii) Write down the equation of particle coarsening due to the Gibbs-Thomson effect. (3)  
(iv) What are the factors that influence particle coarsening? (4)

(OR)

14. b. Explain the theories of Precipitation hardening.

15. a. Write short notes on the following:

- (i) Massive transformation, (ii) Recovery: the stage-I of annealing, (iii) Dependence of recrystallization temperature on various parameters, (iv) Polygonization

(OR)

15. b. What are the effects of time, temperature, strain and other variables on recrystallisation? Explain.

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