VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, BURLA
DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
SESSION 2015 - 16 (EVEN SEMESTER)

Total Pages—6

(Set-R_1)

B.Tech - 6th

Phase Transformation & Heat Treatment

Full Marks : 70

Time : 3 hours

Answer **six** questions including **Q. No. 1** which is compulsory

The figures in the right-hand margin indicate marks

1. Answer the following in short : 2 × 10

   (*a*) Define phase and degree of freedom.

   (*b*) What is the difference between phase diagram and equilibrium diagram ?

   (*c*) Find the number of degrees of freedom for a system having equal number of components and phases.

   (*d*) Draw the cooling curves of pure metal and alloy and explain the differences.

(*Turn Over*)

(*e*) Why lever rule is used ?

(*f*) What is the purpose of heat treatment of steel ? Explain briefly.

(*g*) What are the differences in microstructure of annealed and normalized plain carbon steel ?

(*h*) Why quenched steel has to be tempered ? Define Austempering and martempering.

(*i*) Show schematically the changes in microstructure of a hypo-eutectoid steel on heating to a temperature above 910°C from room temperature.

(*j*) Draw the microstructures of fine grained coarse grained, elongated and dentritic structures of any steel specimen at the same magnification.

2. (*a*) What is annealing ? What are its aims ? Discuss the different types of annealing processes giving the temperature ranges and the aims of each type. 5

(*b*) With the help of suitable diagram, explain the process of martempering. How does it differ from austempering ? What do the microstructures of martempered and austempered steels consists of ? What are limitations ? 5

3. (*a*) Describe the following processes : 5

(*i*) Sub zero treatment

(*ii*) Patenting.

(*b*) Calculate the hardenability (D1) of steel composition : 5

C = 0·4%, Mn = 0·7, P = 0·04, S = 0·04, Si = 0·3, Ni = 1·8, Cr = 0·8, Mo = 0·25 and ASTM grain size = 8, what could be critical diameter (DC) in water and oil. What severity of quench would be required to fully harden the bar of 3" in diameter ?

4. (*a*) Compare gray, malleable, nodular and white cast irons with respect to (*i*) composition

and heat treatment, (*ii*) microstructure, and (*iii*) mechanical characteristics. 5

(*b*) Discuss the influence of the following elements on the structure and properties of cast iron. (*i*) Si (*ii*) Mn (*iii*) S and (*iv*) P. 5

5. Draw the TTT curve of eutectoid steel indicating the beginning and ending of phase transformations, various phases and superimpose with the CTT curve. What is the critical cooling rate ? 10

6. (*a*) Do you expect any difference in room temperature self diffusion coefficients of Al just quenched from 600°C to room temperature and the one slowly cooled to room temperature ? Explain. 2

(*b*) The diffusivity of gallium in silicon is 8×10^{-17} m^2/s at 1100°C and 1×10^{-14} m^2/s at 1300°C. Determine D_0 and Q_d for diffusion of gallium in silicon and calculate diffusivity at 1200°C. 2

(c) Draw the phase diagrams of eutectic and partial eutectic system indicating the various phases. 6

7. (a) Concentration of copper in an aluminium slab decreases linearly from 0·4 at % Cu at the surface to 0·2 at % Cu at 1 mm below the surface. Calculate the flux of copper atoms across a plant 0·5 mm below the surface at 500°C. Lattice parameter of Al is 0·405 nm. 4

(b) Explain why activation energy for the grain boundary diffusion is lower than the activation energy for the lattice diffusion. 3

(c) Derive Fick's second law from the mass conservation with the help of Fick's first law. 3

8. (a) Derive the expression for Homogeneous nucleation (ΔG^* and r^*) and it's rate, and heterogeneous nucleation (ΔG^* and r^*) and its rate (neglect the strain energy). 3

(b) Assume for the solidification of nickel that nucleation is homogeneous, and the

number of stable nuclei is 10^6 nuclei per cubic meter. Calculate the critical radius and the number of stable nuclei that exist that the following degrees of supercooling : 200 K and 300 K. and what is significant about the magnitudes of these critical radii and the numbers of stable nuclei ? [r_{Ni} – 0.255 J/m², $\Delta H_f = -2.53 \times 10^9$ J/m³, Super cooling value for Ni = 319°C]. 4

(*c*) Differentiate between Homogeneous and Heterogeneous nucleation. In which case nucleation rate will be high ? Why ? 3