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

Total Pages—6

(Set-L)

B.Tech-3rd

Introduction to Physical Metallurgy

Full Marks : 70

Time : 3 hours

Q.No.1 is compulsory and answer any **five** from the rest

The figures in the right-hand margin indicate marks

1. Answer the following in short : 2 × 10

(*a*) Show the plane (111) and [110] direction in cubic crystal.

(*b*) If the lattice parameter of Alpha iron is 286 pm, what is its atomic radius ?

(*c*) Copper has FCC crystal structure and the unit cell with a lattice constant of 0·361 nm. What is the inter-planar spacing of d111 planes ?

(*d*) What is Burger's vector ?

(*Turn Over*)

(*e*) Write down Hall-Petch equation and mention its significance.

(*f*) What is peritectic reaction ?

(*g*) State Gibb's phase rule. What is the minimum and maximum number of phases which could exist in a pure metal ?

(*h*) Draw the phase diagram of pure Fe (from room temp ownwards).

(*i*) For an ASTM grain size of 4, approximately how man grains would be there per square inch in a micrograph taken at a magnification of 100X ?

(*j*) Compare properties of plain carbon steels and HSLA Steels.

2. (*a*) What is atomic packing factor ? Show that atomic packing factor of FCC crystal structure is 0·74. 5

(*b*) Cu has atomic radius of 0·128 nm. The atomic weight of Cu is 63·5 g/mol. Compute its theoretical density. 5

3. (a) State the Hume-Rothery rules that favours substitutional solid solution.

(b) Differentiate Frenkel and Schottky defects.

(c) Calculate the equilibrium number of vacancies per cubic meter of copper at 1000°C. The energy for vacancy formation is 0·9 eV/atom. The atomic weight and density at 1000°C for Cu is 63·5 g/mol and 8·40 g/cc respectively. Boltzmann constant $k = 8{\cdot}62 \times 10^{-5}$. 10

4. (a) Differentiate between edge dislocation and screw dislocation with neat sketches.

(b) Explain critical resolved shear stress and derive Schmid's law.

(c) If aluminium deforms at an axial tension of 6·9 MPa in direction [010] on (111) [110] slip system. What is its critical resolved shear stress ? 10

5. Two metals, X [Melting point = 1300 °C] and Y [Melting point = 1000 °C], are partially

miscible. They form two solid solutions α and β. Under equilibrium conditions, maximum conditions, maximum solubility values are given in the following table :

Temperature (°C)	0	200	400	600	800	900	950
Max. solubility of *Y* in *X* [wt. %]	3	10	20	32	50	40	35
Max. solubility of *X* in *Y* [wt. %]	2	2	3	5	10	5	3

A eutectic reaction occurs when the alloy contains 20 wt. % of *X* production both α and β phases : 10

(*a*) Based on the given information, construct an appropriate equilibrium phase diagram and label each phase.

(*b*) An alloy containing 60 wt% of *X* is slowly cooled under equilibrium cooling conditions to room temperature from temperature just above the melting point of *X*. Discuss the phase transformation which will take place and calculate the percentage of α at 200 °C.

(*c*) Outline the heat treatment you would recommend for the above alloy to obtain a very fine dispersion of β phase.

6. (*a*) Describe the changes in micro-structures, with suitable sketches, when cooled slowly from austenite to room temperature for

(*i*) Hypo-eutectoid plain carbon steels

(*ii*) Eutectoid carbon steels and

(*iii*) Hyper-eutectoid plain carbon steels. 5

(*b*) Draw properly the T-T-T diagram of eutectoid plain carbon steel. State its utility and limitations. Define critical cooling rate. 5

7. (*a*) Differentiate between the following : 5

(*i*) Hot working and Cold working

(*ii*) Recovery and Recrystallization.

(*b*) Discuss the mechanism of Age hardening of Al alloys. 5

8. (*a*) Explain Fick's first and second laws of diffusion. 4

(*b*) An FCC iron-carbon alloy initially containing 0·20 wt % C is carburized at an elevated temperature and in an atmosphere wherein the surface carbon concentration is maintained at 1·0 wt %. If after 49·5 h the concentration of carbon is 0·35 wt% at a position 4·0 mm below the surface, determine the temperature at which the treatment was carried out. 6
