STUDY GUIDE FOR COMPREHENSIVE EXAM
MATERIALS PROCESSING
2010

MECH 370 – Principles of Materials Processing
Text Book – Phase Transformations in Metal and Alloys, 2 nd.or 3rd. Edition, D.A. Porter and K.E. Easterling (Chapman & Hall, or Nelson Thornes editions)

Sections to be Covered:

I. Thermodynamics (All Chapter 1, except 1.7)
  a. Gibb's Free Energy and Chemical Potential, 1.1-1.2
  b. Binary Solid Solutions, 1.3.1-1.3.5, 1.3.7-1.3.8
  c. Real Solutions, 1.3.6
  d. Equilibrium Binary Phase Diagrams, 1.5
  e. Interfaces, 1.6, 3.1
    i. Surface Tension, 3.1
    ii. Gibb's Thomson Effect, 1.6
  a. Eyring Rate Theory, 1.9
  b. Chemical Potential as a Driving Force, 2.4
  c. Continuity Equation, 2.4
  d. Atomistic Models, 2.1
    i. Self, 2.3.1
    ii. Interstitial, 2.2
    iii. Substitutional, 2.3
  e. Diffusion Paths, 2.7
  a. Nucleation & Growth 4.1-4.2
    i. Homogeneous
    ii. Heterogeneous
  a. Nucleation
    i. Homogeneous, 5.1
    ii. Heterogeneous, 5.2
  b. Growth
    i. Interfaces, 3.4
    ii. Precipitate Growth, 5.3
    iii. Kinetics (JMA) 5.4
  c. Recovery, Recrystallization and Grain Growth
    i. Descriptions of Grain Boundaries, 3.3.1-3.3.2
    ii. Driving Force for, 3.3.3-3.3.4
    iii. Zener Pinning, 3.3.5
  d. Age Hardening, 5.5.1-5.5.4
  e. Spinodal Decomposition, 5.5.5

II. Diffusion (All Chapter 2, except 2.6 and 2.8)
III. Solidification (4.1 and 4.2)
IV. Diffusional Transformations (Chapter 5)

f. $\gamma \rightarrow \alpha$ and other
   i. ferrite to austenite, 5.6
   ii. eutectoid reaction, 5.8
   iii. massive transformations, 5.9
   iv. ordering transformations, 5.10
a. Characteristics of, 6.1
b. Bain model – FCC → BCT, 6.2
c. Hardenability of Steel (TTT diagram), 5.8, 6.6, 6.7.1

V. Diffusionless Transformations (parts of Chapter 6)

Sample Short Questions:

Explain the following using simple diagrams, if needed:

a) What the driving force is for the formation of the transition phases in a Cu-1.9wt.%Be alloy undergoing the transformation: **supersaturated solid solution → G.P. zones →** $\gamma' \rightarrow \gamma$**.**

b) Recrystallization behaviour was observed to follow the J-M-A relationship ()nktexp1)t(f−−=, where f(t) is the fraction recrystallized. Would you expect n, or k to be temperature dependant? Explain.

c) Why the grain boundary diffusion rate is higher than bulk (volume) diffusion rate at lower temperatures, and the reverse at higher temperatures.

d) Why the self-diffusivity of pure Al rapidly quenched from 600°C is higher than the steady-state value by a factor of 10^8-10^9.

e) Why dendrites form when a solid grows in a liquid (or when snowflakes form).

f) Why ΔG_v for solidification increases with increasing undercooling (ΔT) below the equilibrium melting temperature (T_m).

g) Why an undercooling (ΔT) is required for homogeneous nucleation of a second phase.

h) Why the equilibrium solubility of a dispersed phase in a 2-phase mixture increases as the particle size decreases.

i) Why the nucleation rate for phase transformations exhibits 'C-curve kinetics' (i.e., first increases with decreasing temperature, then decreases).

j) Why heterogeneous nucleation (on g.b.'s, dislocations, pre-existing, phases….) is the dominant nucleation mechanism in solid-solid phase transformations.

k) Why a diffusionless (martensite) transformation is called a 'shear'transformation.

l) How the Continuous-Cooling-Transformation (CCT) diagram for steel can be used to determine its hardenability.

m) How a dispersion of stable second-phase precipitates can prevent grain growth during high temperature annealing.