MATE 313

Fall 2019

Homework # 5

Due: December 9th, 2019 (lecture time)

Group submission (up to 3 students per group) is allowed.

Question 1:

A certain phase transition (α phase → β phase) is found to obey the Avrami relationship, with n = 3.75, and k = 0.003 at a given temperature.

Determine the rate of the transformation process at this temperature.

Question 2:

During the ageing of a Cu-Co alloy, the spherical Co precipitates coarsen such that they double their initial size after 14 hours at 527°C and triple their initial size after 8 hours at 577°C. Calculate the activation energy for this process assuming that its volume diffusion controlled.

The Ostwald ripening equation for coarsening is $r_t^3 - r_0^3 = K * \gamma * X_e * D * t$

Assume that K, γ and X_e are constant in this temperature range.

Question 3:

As a metallurgical and materials engineer, you are given two different precipitation hardening alloys; an A-B alloy with 8 at.% B and an A-C, alloy with 6 at.% C and asked to choose one of the two to work at a high temperature T_x. Which alloy would you choose based on the information given below for T_x? Support your choice with some satisfactory explanation and possible calculations.

a) **A-B system has B rich β precipitates in an α phase matrix whereas A-C system has C rich ε precipitates in the α phase matrix.**

b) **At T_x, the equilibrium solubility of B in α phase near very large β particles is 3 at.% whereas the equilibrium solubility of C in α phase near very large ε particles is 5 at.%.**

c) **The diffusion coefficient of B atoms in α phase is 2×10^{-9} m^2/s whereas the diffusion coefficient of C atoms in α phase is 4×10^{-9} m^2/s**

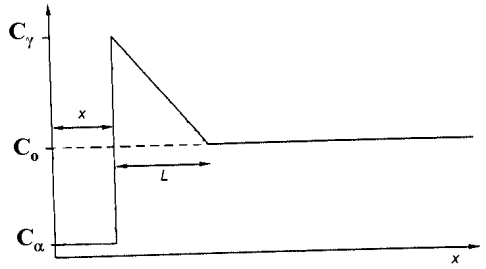
d) **The interfacial energy for the α/β interface is 0.4 J/m^2 and that for α/ε interface is 0.7 J/m^2.**

e) **The precipitate growth mechanisms for both alloy systems are not interface controlled.**

Question 4:

After a full austenitization at 925°C, an Fe-C alloy of 0.15 wt. % C is quenched to 750°C where ferrite nucleates and covers the austenite grain boundaries. Calculate the speed (v = dx/dt) of the α/γ interface when the length of the diffusion field (L) is 0.80 microns.

Given: Atomic weights of Fe and C are 55.86 and 12.01 g/mole, respectively. Take the density of Fe and C as 7.70 and 2.1 g/cm³, respectively.



Question 5: Fill in the blanks

- As compared to grain boundaries, ΔG* can be reduced even further by …….. on grain edges or …….
- In homogeneous transformations such as spinodal decomposition, there is no …….. stage, which means that these transformations occur without the …….. and …….. of an interface.
- A reaction is …….. if it needs the presence of at least two phases to proceed at the rate it does.
- In age hardening, specimens aged short of peak hardness are referred to as ……..
- In a nucleation + growth type phase transformation, when all potential nucleation sites are consumed in the process this is known as ……..
- If an alloy containing GP zones is heated to above the GP zone solvus, the zones will dissolve. This is known as ……..
- In a two phase alloy, a …….. density of small precipitates will tend to coarsen into a *lower* density of larger particles with a …….. total interfacial area. This is called as Ostwald …….. or particle ……..
- Potential sites for heterogeneous nucleation in solids are i) excess vacancies, ii) ……., iii) grain boundaries, iv) ……., v) ……., and vi) free surfaces.