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AMSE502 Phase Transformations

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Problem Set #7

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1. The system A-B exhibits regular solution behavior in the solid state. Answer parts (a) through (e), each when η, the linear strain per unit composition difference, is equal to (i) 0 and (ii) 0.06.

   a) Calculate the critical temperature for solid miscibility.

   b) What is the temperature of the spinodal for the solutions of composition X_B= 0.75 and X_B = 0.60?

   c) What is the critical wavelength at T = 775 K for the two solutions of part (b)?

   d) What is the fastest growing wavelength at T = 775 K anywhere in the A-B system?

   e) What is the maximum value of the amplification factor, R(β), at 775 K anywhere in the A-B system?

   Data

regular solution interaction parameter,	Ω = 15 KJ/mol
gradient energy coefficient,	$K = 10^{-9}$ J/m
Young's modulus,	$E = 10^{11}$ Pa
Poisson's ratio	ν = 0.3
self-diffusion coefficient,	$D_A^* = D_B^* = 10^{-3}$ exp(-100 kJ/RT) m^2/sec
atomic masses,	M_A = 195 g/mol; M_B = 197 g/mol
densities,	ρ_A = 21.5 g/cm^3; ρ_B = 19.7 g/cm^3

2. The rate of development of compositional fluctuations by spinodal decomposition into zones can be written as

$$C_A(x,t) = C_A(x,0)\ \exp(-\pi^2 Dt/\lambda^2)$$

where $C_A(x,t)$ represents the maximum concentration of species A.

   (a) What effect does increasing the transformation time by a factor of 10 from 10s to 100s at room temperature have on the maximum concentration of A when $\lambda = 0.01\,\mu$m and $D_A = 10^{-4}\exp(-85000J/RT)$ m^2s^{-1}?

   (b) Compare the maximum concentrations after 100s at room temperature when the fluctuation wavelength changes by a factor of 10 from 0.1 μm to 0.01 μm.

   (c) Compare the maximum concentrations after 100s for fluctuations of wavelength 0.01 μm in a sample processed at room temperature with those of a similar sample processed at 100K above room temperature.

   (d) In view of the above calculations, to which physical metallurgical factor is the transformation kinetics most sensitive?