Department of Materials Science and Engineering
Norwegian University of Science and Technology

TMT4320 Nanomaterials, fall 2015

EXERCISE 4

Guidance: Wednesday 16th September, 18:15-20:00, H3
Due date: Friday 18th September, 14:00, boxes outside R7 or in It's learning

PROBLEM 1

The energy ΔG of a nucleus of a new phase of size r appearing in a homogeneous mixture can be described as a sum of a volume term and a surface term:

$$\Delta G = \Delta\mu_V + \Delta\mu_S = \frac{4}{3}\pi r^3 \Delta G_V + 4\pi r^2 \gamma$$

where ΔG_V is the change of Gibbs energy per unit volume of the solid phase and γ is the surface energy. Use this equation to derive expressions for the critical size of a stable nucleus (r^*) and the critical energy (energy barrier for nucleation, ΔG^*) as functions of ΔG_V and γ.

PROBLEM 2

a) Use Figure 1 below to explain in your own words (not copy paste from a book) the concept of nucleation and growth in the transition from a single phase to two phases, for instance the formation of solid nanoparticles in a solution. Fill in the appropriate axes, areas and limits.

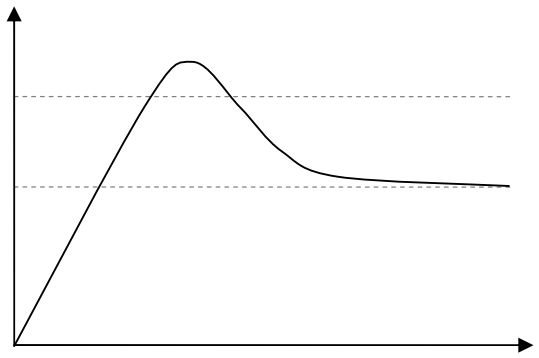

Figure 1.

b) What is the main difference between nucleation-and-growth and spinodal decomposition?

c) In Figure 2 below, which of the two lines A-B and C-D represents nucleation-and-growth and which line represents spinodal decomposition? Assume the material is quenched.

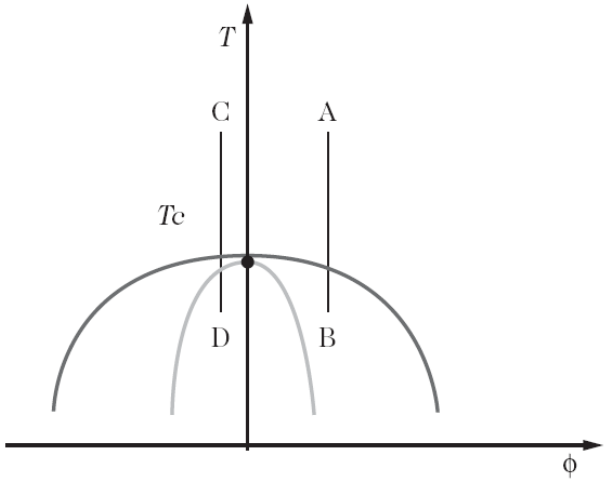

Figure 2. Phase diagram of a system with order parameter ϕ. *T*: temperature. *Black curve*: boundary for coexistence of the two phases (binodal curve). *Grey curve*: spinodal curve.

d) During the transition from the homogeneous phase to the spinodal region of the two-phase region, is it possible to observe nucleation-and-growth? Explain how and why.

PROBLEM 3

a) Draw the molecular structure of a cationic surfactant, an anionic surfactant and a non-ionic surfactant and name the three surfactants.

b) What is the difference between a micelle and a reverse micelle? Draw the two structures.

c) How can reverse micelles be used for synthesis of nanoparticles? As an example, explain how you would produce cobolt (Co) nanoparticles if you have these compounds available: Water, hexane, $CoCl_2$, $NaBH_4$, and Na(AOT) (sodium bis(2-ethylhexyl)-sulfosuccinate).

d) How can we control the size of nanoparticles synthesized in reverse micelles?