Final Examination

This exam should be answered individually and no contact with other classmates is allowed for the purpose of answering this test. It should be turn in any time before 10:00 am on June13th, and it should be sent via e-mail with the *SUBJECT: Final NMS2020*

# How do you explain from a thermodynamic point of view the Ostwald ripening phenomenon?

The driving force in the Ostwald ripening process is the decrease of the total surface free energy, where large particles grow at the expense of smaller particles. Ostwald ripening occur by the nucleation and growth of particles from an oversaturated solution. The result are dispersed particles with varying sizes depending on the nucleation rate. The dispersed particles do not meet thermodynamic equilibrium as the particles’ configuration is not at the lowest energy due to the excess surface energy. Consequently, the Ostwald ripening process continues to the point where the surface energy is as low as much as possible. The total energy is reduced by the increase of particle size and thus, by the decrease of surface area [1,2].

A solution undergoing the Ostwald ripening process is typically near to the equilibrium of a 2-phase system, but it is not at the lowest energy state possible. The thermodynamic imbalance is due to the polydisperse essence of the mixture and the presence of high surface free energy. The total surface area of the system in time to reach thermodynamic equilibrium. The process by which the particles grow is through diffusion, where mass transfers from particles with high interfacial curvature to particles with low interfacial curvature. Particle growth is triggered by concentration gradients within the solution around the particles. The Gibbs-Thomson relation describes the particle growth by thermodynamic demand, as the concentration at the surface of particles in equilibrium with larger particles is lower than that with smaller particles [1,2].

TODO: explain the Gibbs-Thomson relation

Any system of disperse particles statistically distributed in a medium and possessing certain solubil- ity in it will be thermodynamically unstable due to a large interface area. Its decrease in approaching equi- librium is accompanied by particle coarsening whose solubility depends on their radii and is described by the well known Gibbs-Thomson relation

where:

* is the solute concentration at a plane interface in the matrix in equilibrium with particle of infinite radius,
* is the solubility at the surface of a spherical particle with radius r,
* is the specific interfacial energy of the matrix-precipitate particle boundary,
* is the mean atomic (or molar) volume of the particle,
* is the Universal gas constant [8.314×103 J /(K. kmol)] and
* is the absolute temperature.

The difference between and induces a diffusive flux of atoms from the smaller to the larger particles. Thus, the average particle radius increases and the total number of particles decreases with time, as well as the total free surface enthalpy of the system.

# A nanolayer of atoms are deposited through a chemical reaction on a flat surface and you are asked to develop a general deposition model considering that the reaction can be a first or second order. Assume that both cases are diffusion controlled, the reaction velocity constants (RVCs) are the same and the diffusion rate is X times that of the RVCs. Write the model and make a drawing (by hand) to depict the phenomenon.

# It was found that a soap solution film with an unknown constant thickness reflects the day light and the resulting reflection is blue with a wavelength of 475 nm. The refractive index of the soap solution is 1.4. What is the thickness of the film?

The following is based on [3].

# You obtained a film of gold on a 1 cm2 silica wafer. The film is 10 nm thick and you are asked to produce gold nano dots:

The following is based on [4–8].

### Write an algorithm of the calculations you must do in order to determine the number of nanodots

### Write the equations, indicating what terms are temperature and surface tension dependent

### Show the calculations of how many nanodots you will get.

### Determine de % of area the nanodots will have on the 1 cm2 silica wafer.

**Note:** Do not use the size of nanodots published in the literature to answer this question. However, you can use reported data for surface tension, density, etc.

# You are being interviewed by the CEO of the company Non-Gray Metals, and they asked you make a 3 slide power point presentation based on the paper: **“Laser coloration of metals in visual art and design”**. You should be very careful and need to be very professional on explaining the phenomenon that makes a metal to have different colors.

# Observe the surface of the gold nanoporous film given in the paper **“Localized surface plasmon resonance of nanoporous gold”**. How would you measure the surface tension and the morphology of the film?

# You want to start your own company on the fabrication of nano-porous membranes. You found the article: **“Nanoporous aluminum oxide membranes for biomedical micro hydraulic devices”** to get started but you want to create a membrane with less pore size dispersion. What factor would you alter to make the distribution narrower?

# References

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