Tutorial problems and questions

1. Using typical values, show that the capillary effects are very important for particles in the range 1-100 nm.

Answer

As seen in Part III of this course notes, assuming the $\alpha$ phase to be a regular solution and the $\beta$ phase to be nearly pure $B_\beta$, one can obtain the composition of the $\alpha$ phase in equilibrium with the $\beta$ phase of radius $r$ as

$$ X_r = X_\infty \left( 1 + \frac{2\gamma V_m}{rRT} \right) $$

(4)

Consider the typical values of 200 mJ/m$^2$ for $\gamma$, and $10^{-5}$ m$^3$ for $V_m$; at 500 K (since $R = 8.31$ J/mol/K), one obtains

$$ \frac{X_r}{X_\infty} \left( 1 + \frac{1}{r \text{ (in mm)}} \right) $$

(5)

Thus, for radii in the nanometre range, there will be considerable changes in equilibrium compositions which become negligible when the length scales are in the micron range.