Soft Matter exercise, Chapter 6: Phase transition

1. Spinodal decomposition

a. Draw the Gibbs free energy as a function of the composition of a binary mixture that phase separates if cooled below the critical temperature for $T_1 < T_c$.
b. Draw a phase diagram that contains the data points that can be extracted from the Gibbs free energy graph you plotted in (a).
c. Indicate the compositions of the two phases formed at T_1 in the Gibbs free energy diagram you made in (a) and in the phase diagram you made in (b).
d. What is spinodal decomposition and when does it occur?
e. If spinodal decomposition occurs, why can e.g. atoms, molecules, or ions diffuse in the opposite direction to their concentration gradient?
f. Sketch the microstructure of a polymer mixture that underwent spinodal and binodal decomposition respectively. What is different?

2. Solubility

The value of χ between water and linear hydrocarbons may be approximated as $\chi = 3.04 + 1.37 n_C$ where n_c is the number of carbons contained in the hydrocarbon chain.

a. Calculate the solubility of hexane in water at 25°C
b. Calculate the solubility of octane in water at 25°C
c. Calculate the solubility of dodecane in water at 25°C.

3. Phase diagram of a liquid mixture

The phase behavior of a polymer solution can be described by the regular solution model, with the interaction parameter being χ = 600 K/T, where T is the temperature.

a. Calculate the temperature at the critical point.
b. Does the system phase separate at 273 K?
c. Calculate the volume fractions of the two co-existing phases at 5°C.
d. What would change if you have a polymer that is dissolved in a solvent if the polymer has 1000 repeat units? Would the interaction parameter change? If yes, why? If no, why not?

4. Phase diagram of a polymer mixture

You prepare a mixture of two polymers whose critical composition is $\Phi_{c,1}$= 0.4. You prepare the mixture above the critical temperature, where the two phases are soluble and subsequently cool the mixture below the temperature of the critical point. Describe the microstructure of a mixture composed of

a. Φ_1= 0.3 and Φ_2= 0.7.
b. Φ_1= 0.4 and Φ_2= 0.6.
c. What is $\Phi_{c,1}$ of an ideal solution? Why can it be different for polymer solutions?