

Suspensions and polymer solutions

Exercise 6

1 January 2007

A polyelectrolyte is a polymer whose monomers may be charged. Consider a polyelectrolyte chain consisting of N monomers of length a , an average fraction φ of which are monovalently charged.

1. Apply the Flory argument to write down the free energy of the chain. Note that the electrostatic interaction is long-ranged and, hence, we cannot use the virial expansion to describe it. Instead, recall that the energy associated with a charged object of size R (e.g., a charged sphere of radius R) is $\sim Q^2/(\varepsilon R)$, where Q is the total charge of the object and ε the dielectric constant of the medium.
2. Calculate the equilibrium extent of the chain, R , as a function of N , φ , and a .
3. What is the value of the swelling exponent ν and the dimensionality D ? What is the meaning of this result?

Remark: As we discussed earlier in the course, in real solutions there are always mobile ions which screen the electrostatic interactions beyond the Debye screening length κ^{-1} . The result that you have obtained is valid, therefore, only as long as $R < \kappa^{-1}$.