

# Chemical physics of polymer solutions

## Exercise 5

15 December 2003

A polyelectrolyte is a polymer whose monomers may be charged. Consider a polyelectrolyte chain consisting of  $N$  monomers of length  $a$ , an average fraction  $\varphi$  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  $\varepsilon$  the dielectric constant of the medium.
2. Calculate the equilibrium extent of the chain,  $R$ , as a function of  $N$ ,  $\varphi$ , and  $a$ .
3. What is the value of the swelling exponent  $\nu$  and the dimensionality  $D$ ? What is the meaning of this result?

*Remark:* In real polyelectrolyte solutions there are always mobile ions that screen electrostatic interactions beyond a certain screening length  $\lambda$ . The result that you have obtained is valid, therefore, only as long as  $R < \lambda$ .