Physical Chemistry of Interfaces:
Exercises *Session 6*

note: the product $\varepsilon_0\varepsilon_r$ is equal to the permittivity ε defined in the lecture notes.

6.1 Debye length

The Debye Hückel parameter is given by:

$$\kappa = \left(\frac{F^2 \sum_i c_i z_i^2}{\varepsilon_0 \varepsilon_r RT}\right)^{\frac{1}{2}} \qquad [\mathrm{m}^{-1}]$$

where F is the Faraday constant, ε_0 is the permittivity of the vacuum, ε_r is dimensionless relative permittivity and c is concentration of the ions in mol m^{-3}.

F=96485 C mol^{-1}, $\varepsilon_0 = 8.8510^{-12}$ C $V^{-1}m^{-1}$, $\varepsilon_r = 78.5$, R=8.314 $JK^{-1}mol^{-1}$

Check the units of the variables and find the unit of κ. Calculate the Debey length for the following concentrations of salts in water at 25 ° C:

a) 10^{-2} M KCL
b) 10^{-6} M KCL
c) 10^{-3} M NaCl + 10^{-4}M Na_2SO_4

6.2

For an electrophysiological experiment you form an electrode from a 5 cm long platinum wire (0.4 mm diameter) by bending it in the shape of a spiral. Calculate the total capacitance of the diffuse electric double layer for aqueous solutions of a monovalent salt at concentrations of 0.1 and 0.001 M. Assume a low surface potential.

6.3 The differential capacitance of a mercury electrode in an aqueous medium containing NaF has been measured at the point of zero charge. It is 6.0 μF/cm² at 1 mM, 13.1 μF/cm² at 10 mM, 20.7 μF/cm² at 100 mM, and 25.7 μF/cm² at 1 M concentration. Compare this with the result of the Gouy–Chapman theory and draw conclusions.

6.4 Micellization is driven by the hydrophobic effect. Estimate from measured CMCs of alkylethylene glycols (e.g. for C_8E_6 and $C_{12}E_6$; CMCs are 9.8 and 0.08mM, respectively) the change in the Gibbs free energy for bringing one methylene group ($\sim CH_2 \sim$) from an aqueous medium into the interior of a micelle.