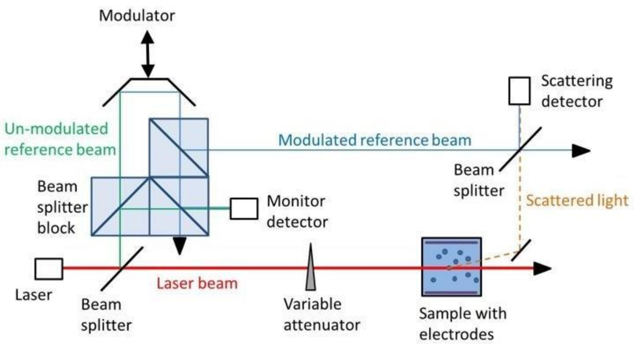
1. The Debye parameter (κ) is a very important parameter that helps to describe the structure of the electrical double layer. It is important to know that κ ~$I^{1/2}$. I is the ionic strength ($I = \frac{1}{2} \sum c_i * z_i^2$) that plays a central role in the Debye–Hückel theory and in describing electrokinetic phenomena in colloids and other heterogeneous systems.

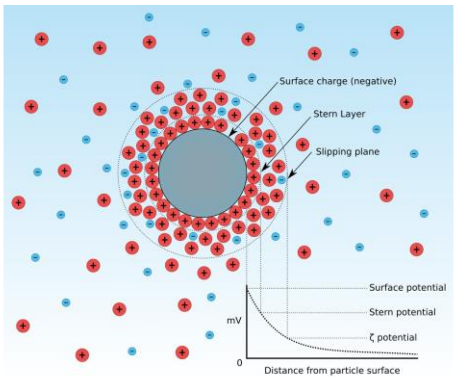
a) Determine the Ionic strength (don't forget to write the units of ionic strength) and the Debye length in water at room temperature (25°C) as a function of the concentration for a solution of NaCl, $CaCl_2$, and $MgSO_4$. (Relative permittivity of water ε_R=78.4).

b) For the case of NaCl at 0.1mM, compare the Debye length of an aqueous solution vs an ethanolic solution (ε_R=24.3).

2. One of the ways to characterize the charges on nanoparticles and their interactions with an electrolyte solution is using a Zeta Potential instrument. This instrument is based on electrophoretic mobility, i.e., the particle solution is placed on an alternating electric field, and their mobility (speed/electric field) can be measured by illuminating the sample with a laser and analyzing the outgoing beam (either by a Doppler or by a phase analysis). The zeta potential (Potential at the slipping plane) can be calculated using Henry's equation:

$$\mu_E = \frac{2\varepsilon\zeta f(\kappa a)}{3\eta}$$





where ζ is the zeta potential η is the viscosity (1mPa·s for water), a is the radius of nanoparticles, and f(κa) is a Henry's coefficient that is taken as 1.5 for κa >>1 and 1 for κa <<1 (Smoluchowsky's and Huckel's approximations respectively).

a) Calculate the Debye length for 10 mM NaCl solution and 20 nm diameter nanoparticles.

b) What do you think would happen to the zeta potential if we increase the salt concentration? What would happen if we substitute the salt by one with divalent ions?

c) Given a zeta potential of 20 mV at 25° C calculate the electrophoretic mobility using the conditions in a).

d) If the slipping layer were at the stern layer, what would be the total density of charges on the nanoparticle (including the density at the surface plus the density at the stern layer)?