Chapter 4

1. What is difference between electrophoresis and electroosmosis?

   Ans: In electrophoresis, charged solid particles move under external electric field.

   In electroosmosis, liquid with free charge move under external electric field where charged solid is stationary.

2. What is Zeta potential?

   Ans: The potential at the stationary outer surface of a charged surface is zeta potential.

3. What is the condition of Debye-Huckel approximation?

   Ans: Surface potential is less than 25 mv.

4. What is the scaling length of electric double layer?

   Ans: Debye length.

5. A protein solution in 0.05M NaCl is ultrafiltered with mass transfer coefficient 8x10^{-5} m/s. Filtration is gel layer controlled with gel concentration of 100 kg/m^3 and feed concentration 1 kg/m^3. Charge on protein is 5e and radius is 7 nm.

   (a) What is permeate flux?

   (b) If 500 V/m external electric field is applied, what is permeate flux?

   Ans: K=8X10^{-5} m/s; C_g=100 kg/m^3; C_0= 1 kg/m^3

   (a) J= k \ln \frac{C_g}{C_0}

   =8.5 \times 10^{-5} \ln \frac{100}{1} = 3.7 \times 10^{-4} \text{ m/s}

   (b) \kappa^2 =(\text{inverse of Debye length})^2
\[ \frac{2000 N_A m e^2}{\varepsilon k_B T} \]

\[ = \frac{2000 \times 6.023 \times 10^{23} \times 0.05 \times (1.6 \times 10^{-19})^2}{80 \times 8.85 \times 10^{-12} \times 1.38 \times 10^{-23} \times 300} \]

\[ \kappa^{-1} = 1.38 \times 10^{-9} \text{ m} \]

\[ \nu_e = \frac{\varepsilon \xi E}{\mu} \]

\[ \xi = \frac{Q}{4\pi \varepsilon a (1 + \kappa a)} \]

\[ = \frac{5 \times 1.6 \times 10^{-19}}{4 \times 3.14 \times 80 \times 8.85 \times 10^{-12} \times 7 \times 10^{-9} \times (1 + \frac{7 \times 10^{-9}}{1.38 \times 10^{-9}})} \]

\[ = \frac{8 \times 10^{-19}}{6.22 \times 10^{-17} (6.07)} \]

\[ = 2.1 \text{ mV} \]

\[ \nu_e = \frac{80 \times 8.85 \times 10^{-12} \times 2.1 \times 10^{-3} \times 500}{10^{-3}} \]

\[ = 7.43 \times 10^{-7} \text{ m/s} \]

\[ J_{e} = J + \nu_e = 3.7 \times 10^{-4} + 7.43 \times 10^{-7} \]

\[ = 3.7 \times 10^{-4} \text{ m}^3/\text{m}^2.\text{s} \]