

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 8×10^{-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: $K=8 \times 10^{-5}$ m/s; $C_g=100 \text{ kg/m}^3$; $C_0=1 \text{ kg/m}^3$

$$(a) J = k \ln \frac{c_g}{c_0}$$

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

(b) $\kappa^2 = (\text{inverse of Debye length})^2$

$$= \frac{2000 N_A M e^2}{\epsilon k_B T}$$

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

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

$$v_e = \frac{\epsilon \xi E}{\mu}$$

$$\xi = \frac{Q}{4\pi\epsilon a(1+\kappa a)}$$

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

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

$$= 2.1 \text{ mV}$$

$$v_e = \frac{80 \times 8.85 \times 10^{-12} \times 2.1 \times 10^{-3} \times 500}{10^{-3}}$$

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

$$J_e = J + v_e = 3.7 \times 10^{-4} + 7.43 \times 10^{-7}$$

$$= 3.7 \times 10^{-4} \text{ m}^3/\text{m}^2 \cdot \text{s}$$