

Problem Set 5

1. a. $P(r) \propto e^{-2Ce^2 \ln r / D\epsilon kT} = e^{-2\epsilon \ln r}$

b. $rP(r) \propto re^{-2\epsilon \ln r}$

$$0 \leq r \leq r_0 \Rightarrow \int_0^{r_0} rP(r) dr = \int_0^{r_0} re^{-2\epsilon \ln r} dr$$

$$= \int_0^{r_0} r (e^{\ln r})^{-2\epsilon} dr = \int_0^{r_0} (r)(r^{-2\epsilon}) dr = \int_0^{r_0} r^{1-2\epsilon} dr$$

$$\left(\frac{1}{2-2\epsilon} \right) r^{2-2\epsilon} \Big|_0^{r_0}$$

c. The 0 limit could be problematic. This limit is only finite when $2-2\epsilon > 0 \Rightarrow 1-\epsilon > 0 \Rightarrow \epsilon < 1$

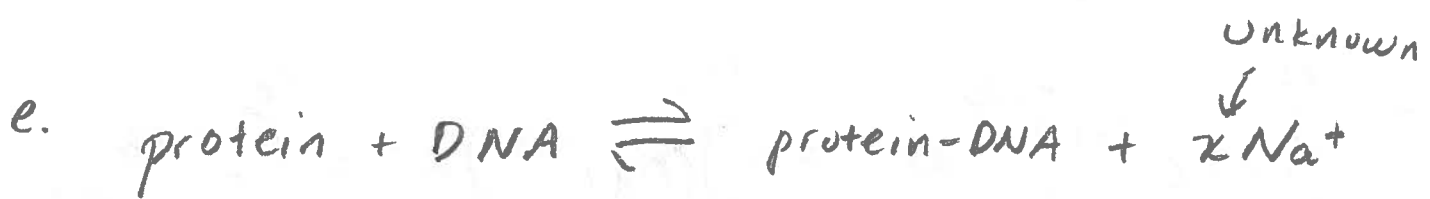
d. If cations become closely associated with DNA, this has the effect of increasing b .

For $\epsilon b_1 = \frac{Ce^2}{D\epsilon kT}$, $\epsilon = 1 \Rightarrow b = \frac{2.0 \times 10^9 \text{ J}\cdot\text{m}}{e^2}$

$$b = \left(9.0 \times 10^9 \frac{\text{J}\cdot\text{m}}{\text{C}^2} \right) (1.6 \times 10^{-19} \text{ C})^2 / (78)(1.38 \times 10^{-23} \text{ J})(310) = 6.9 \text{ \AA}$$

So, $\sim 3/4$ of the negative charges (5.1 \AA°) of DNA are neutralized by cations

$$\frac{\text{charge (DNA + cation)}}{\text{charge (DNA)}} \approx \frac{1}{4}$$



$$\log \frac{[\text{protein-DNA}] [\text{Na}^+]^{\chi}}{[\text{protein}] [\text{DNA}]} = \log K_{eq}$$

$$\log K_{obs} + \chi \log [\text{Na}^+] = \log K_{eq}$$

$$\log K_{obs} = \log K_{eq} - \chi \log [\text{Na}^+]$$



$$\text{slope} = \chi \approx 10.5$$

f. Add cations (salt) \Rightarrow These cations will compete with protein bindings. From Equation above,
 as $[\text{Na}^+] \uparrow$ $K_{obs} \downarrow$