**CHEM-E3150 Biophysical chemistry. Exam 20.02.2020.**

Please answer all 5 questions (including possible a, b, and c-parts). Calculators are allowed. No other materials allowed. On page 2 there is a list of possibly useful equations and relations. Show clearly how you came to your conclusions.

**1.** The free concentration of a ligand was kept constant at $1*10^{-7}$ M. It is bound to a receptor A with a $K_D$ of 1 nM, and to another receptor B with a $K_D$ of 1 $\mu$M.

a) What is the ratio of the fractional occupancies of the receptors?

b) Draw a graph of the fractional occupancies that illustrates the situation.

c) What happens if we increase the concentration of receptor A to the double?

**2.** A system with 100 000 molecules has two energy levels (A and B). At first, the two energy levels are populated equally. After a reversible process, energy level A is populated by 65% of the molecules and the system is at 293 K.

a) What is the change in entropy?

b) How much heat was added or removed from the system?

**3.** 1000 water molecules surround a hydrophobic particle. They are restricted in movement so that they can take only one of two available positions A or B. The probability of positions A and B are equal.

a) What is the most likely distribution between the two positions?

b) What is the multiplicity of this distribution? Solve using Stirling's approximation and express the result as a power of 10.

c) What is the multiplicity of a case in which the 1000 water molecules could take any of five equally likely positions?

**4.** The unfolding of a protein was studied by differential scanning calorimetry (DSC). The melting temperature of the protein was 110 °C. The measured difference in heat capacity (at constant pressure) between the unfolded and folded protein $\Delta C_p$ was 3,21 $kJK^{-1}mol^{-1}$. The integrated peak area of denaturation in the melting curve, i.e. the heat of unfolding was 333,22 $kJmol^{-1}$.

a) Draw as clearly as possible with the available data, a curve for the temperature dependence of the heat capacity.

b) What would the entropy of unfolding be at 25 °C?

c) How do the enthalpy and entropy components of the free energy of unfolding change with temperature for the protein?

**5.** Imagine proteins diffusing away from an initial sharp point.

a) Draw a picture using the concept of a root-mean-square distance (RMSD) value to explain how the diffusion progresses over time. What determines the value of RMSD?

b) At a distance of 30 $\mu$m, how long time will it take until the probability of finding a protein is 50 % of what it is at the initial point? The diffusion coefficient is 1,11 $*10^{-6}$ $cm^2s^{-1}$ at 25 °C.

Some equations and relations that might be useful:

$$D = \frac{k_B T}{6\pi\eta r}$$

D= kBT/f

r.m.s. distance = $\sqrt{6Dt}$

$$S = -Nk_B \sum_i p_i ln(p_i)$$

$$[LR] = \frac{Bmax * [L]}{K_D + [L]}$$

R= 8.314 $JK^{-1}mol^{-1}$

$k_B$= $1.38x10^{-23}$ $JK^{-1}$

0 °C= 273 K

$$p(x) = \frac{1}{\sqrt{2\pi}} \frac{1}{\sigma} e^{\frac{-(x_{1/2}-\mu)^2}{2\sigma^2}}$$

$$\Delta G = \Delta H - T\Delta S$$

$\Delta G^o$ = RT ln $K_D$

$\Delta S = q_{rev}/T$

$dH=C_pdT$

F=fv

$\mu = \mu^o$ + RTlnC

$S=k_BlnW$

W=M!/(N!(M-N)!)

$n!=(n/e)^n$

$Sv=m_{eff}/f$