Prob-1. In the 'Open' form, the protein domains 'A' and 'B' can independently adopt 27 and 81 microscopic states, respectively, The ligand 'L' can always adopt 3 states.

When shifting from the 'Open' to the 'Bound' state, the interaction energies change as:

ΔE_{A-B}: -35.0 kcal/mol

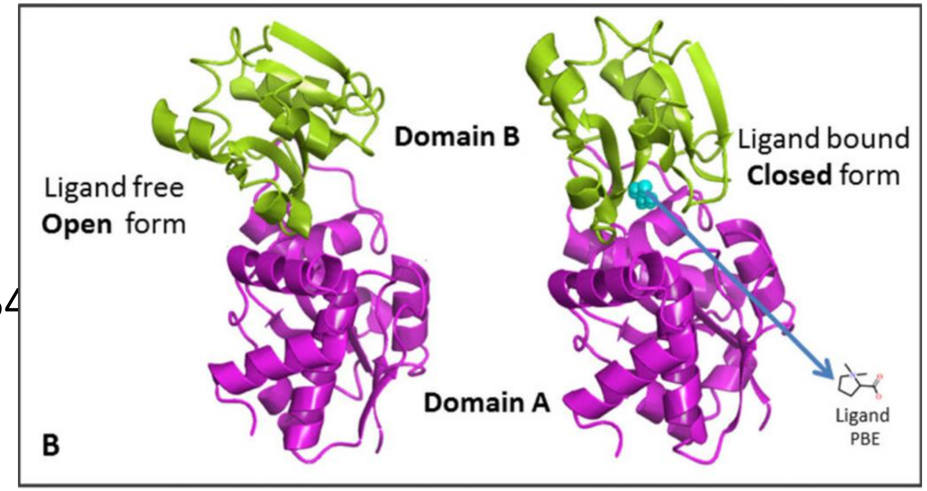
ΔE_{A-L}: -7.0 kcal/mol

ΔE_{B-L}: -4.0 kcal/mol

$$\Delta E_{A-B} = E_{(AB)} - (E_A) - (E_B)$$

Also, the number of states in 'A' and 'B' in the closed form reduce to 18 and 54 respectively.

Open state Bound state



Determine if the 'Open' to 'Bound' transition is spontaneous.

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

$$= \underbrace{(\Delta E_{A-B} + \Delta E_{A-L} + \Delta E_{B-L})}_{\equiv -46.0} - \underbrace{T(\Delta S_A + \Delta S_B + \Delta S_L)}_{-T\left[\left(\ln \frac{S_A^f}{S_A^i}\right) + \left(\ln \frac{S_B^f}{S_B^i}\right) + \ln\left(\frac{S_L^f}{S_L^i}\right)\right]}$$

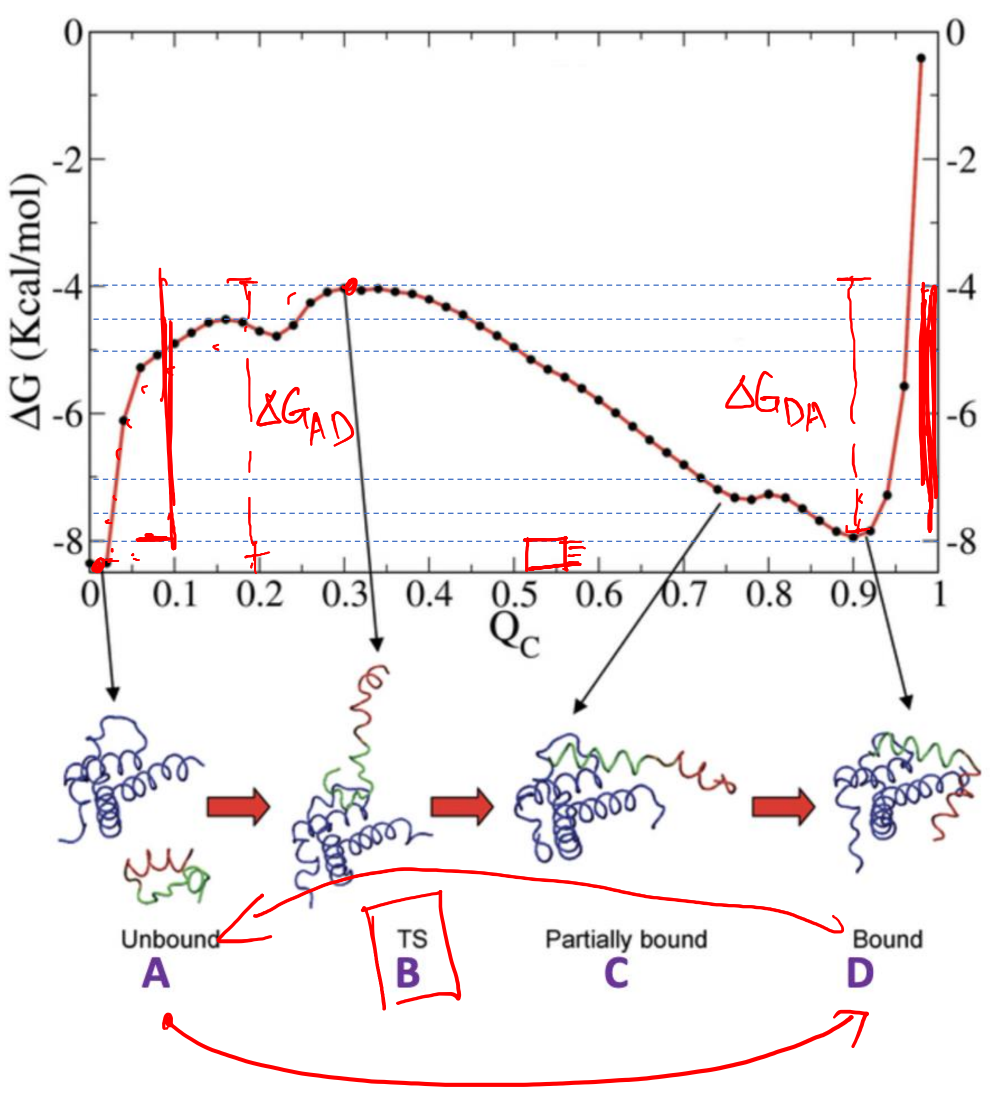
$$\equiv -46.0 - 300R\left[\ln \Omega_{final} - \ln \Omega_{initial}\right]$$

IS THE PROCESS ENERGETICALLY OR ENTROPICALLY DRIVEN?

From "**Binding-Induced Folding of a Natively Unstructured Transcription Factor**". See https://doi.org/10.1371/journal.pcbi.1000060

Prob-2. a) Find the ratio of the probabilities of finding states A, B, C and D at room temperature.

b) Find the ratio of the transition rate from (D → A) and from (A → D), ignoring any intermediary metastable state.



a) $\frac{P_A}{P_B} = \frac{e^{-\beta G_A}}{e^{-\beta G_B}} = e^{-\beta(G_A - G_B)}$

$= e^{-\frac{1}{RT}(-8.5-(-4.0))}$

$= e$

≈ 2300 (check)

Similarly, $\left.\frac{P_A}{P_C}, \frac{P_A}{P_D}\right\} P_A : P_B : P_C : P_D$

b) $\left.\begin{aligned} R_{A\to D} &\propto e^{-\beta \Delta G_{AD}} \\ R_{D\to A} &\propto e^{-\beta \Delta G_{DA}} \end{aligned}\right\} \frac{R_{A\to D}}{R_{D\to A}} = \frac{e^{-\beta \Delta G_{AD}}}{e^{-\beta \Delta G_{DA}}}$

$= e^{-\beta(\Delta G_{AD} - \Delta G_{DA})}$

$=$

$$\frac{k_{A\to D}}{k_{D\to A}} = e^{-\frac{1}{RT}\left[\frac{0.25}{\sim}\right]} \simeq e^{-\frac{0.25}{0.58}}$$

$$\simeq 0.6$$

$$\Delta G_{AB} - \Delta G_{DA}$$

$$= 0.25$$

check

Prob 3. In an experiment (E1), the diffusion coefficient of human Hemoglobin was measured as 8.0×10^{-7} cm^2/s at 35 deg C.
Another experiment (E2) under a different condition measured the value as 6.8×10^{-7} cm^2/s.
If E2 reported a 10% decrease in the average radius of Hemoglobin, what is the closest approximation to the temperature corresponding to E2?
(Assume Hemoglobin's movement was purely diffusive)

$$6\pi \eta a D = k_B T$$

Assumptions:
- Spherical assumption
- η remains constant

$$\frac{a_1 D_1}{a_2 D_2} = \frac{T_1}{T_2}$$

Prob 4. Find the closest approximation to 1 unit of room temperature thermal energy (k_BT_r) in electron Volts (eV).
[1 eV is the work done in moving a charge of 1 electron across a potential difference of 1 volt, in SI units]

Ans: Thermal energy is approximately 0.025 eV at 300K