Bioc 460 Summer 2011

Bioenergetics Practice Questions Answers

1. For the dissociation of a ligand, L, from a membrane receptor, R:

$$LR \Leftrightarrow L + R$$

- The equilibrium constant for dissociation is $K_d = 2 \times 10^{-6}$ M. Intuitively, how much dissociation do you expect, a little or a lot?
- If $[L] = 1 \times 10^{-5}$ M, $[R] = 5 \times 10^{-7}$ M, calculate [LR].
- For the dissociation reaction at equilibrium calculate ΔG^o at 25 °C (as written).
- Which reaction is favored, dissociation or association?

Since K_d is such a small number, you would expect to get very little dissociation.

$K_d = [L][R] / [LR] = (1 \times 10^{-5}\ M)(5 \times 10^{-7}\ M)/[LR] = 2 \times 10^{-6} M$

$[LR] = (5 \times 10^{-12}\ M^2)/ (2 \times 10^{-6}\ M) = 2.5 \times 10^{-6}\ M$

The system is at equilibrium so $\Delta G^o = -RT \ln K_{eq}$

$= -(8.315 \times 10^{-3}\ kJ / K \bullet mol)(298 K) \ln(2 \times 10^{-6} M)$

$= + 32.52\ kJ/mol$

Since $\Delta G^o >> 0$*, the dissociation reaction is not favorable (but we knew that because of the value for* K_d*!).*

2.For the hydrolysis of ATP: $ATP \Leftrightarrow ADP + P_i$

If the **equilibrium** concentrations of ATP = 1×10^{-7} M, ADP = 0.165 M and P_i = 0.1 M, what are the equilibrium constant and $\Delta G^{o'}$ for the hydrolysis of ATP at 37°C?

Use the data to calculate Keq'.

$$Keq' = \frac{[ADP][Pi]}{[ATP]} = \frac{[0.165M][0.1M]}{[1x10^{-7}\ M]}$$

$$=1.65x10^{5}\ M$$

Use the value of Keq' to calculate $\Delta G^{o'}$.

$$\Delta G^{o'} = -RTlnKeq' = -(8.315x10^{-3}\ kJ\ /K\bullet\ mol)(310\ K)ln(1.65x10^{5})$$

$$\Delta G^{o'} = -(2.578)(12) = -31.0kJ/\ mol$$

3. In a typical cell at 37°C the concentration of ATP = 8 x 10^{-3} M, ADP = 1 x 10^{-3} M, and P_i = 8 x 10^{-3} M. What is the actual free energy change ($\Delta G'$) for ATP hydrolysis under these conditions?

The KEY is to recognize that this system is NOT at equilibrium.

$$\Delta G' = \Delta Go' + RT\ ln\frac{[ADP][Pi]}{[ATP]}$$

$$\Delta G' = -31.0kJ/mol + (8.315x10^{-3}\ kJ/mol\bullet K)(310\ K)\ ln\frac{[1x10^{-3}\ M][8x10^{-3}\ M]}{[8x10^{-3}\ M]}$$

$$\Delta G' = -31.0kJ/mol + (-17.8\ kJ\ /\ mol) = -49\ kJ/\ mol$$

4. The conversion of A to E is coupled by the two reactions below:

$A + B \Leftrightarrow C \quad \Delta G^{o'}_{1} = +\ 15$ kJ/mol

$C + D \Leftrightarrow E \quad \Delta G^{o'}_{2} = -\ 35$ kJ/mol

Calculate the total $\Delta G^{o'}$ for the coupled reactions.

$$\Delta G^{o'}_{total} = \Delta G^{o'}_{1} + \Delta G^{o'}_{2} = (+15\ kJ/mol) + (-35\ kJ/mol)$$
$$= -20\ kJ/mol$$

Thus, coupling these two reactions together permits the thermodynamically favorable conversion of A to E.