North Carolina State University Physical Chemistry 331 Quiz #7

Name ____________________________ Section ______ Tuesday, Oct. 26

1. The enzyme glucose oxidase converts glucose to glucolactone and generates one equivalent of hydrogen peroxide. The cofactor flavin adenine dinucleotide (FAD) is required for function. The nucleoside adenine monophosphate is a non-competitive inhibitor that binds to the FAD binding site with an association constant of $K_a = 10^6$ M^{-1}. Glucose oxidase is observed to have a maximal velocity of 1.5 mmol/min for the oxidation of glucose. At a glucose concentration of 10^{-5} M the rate is 0.5 mmol/min.
   A. Determine K_M for glucose oxidase.
   B. Determine effect on the maximal rate if the concentration of adenine is 10^{-3} M.

K_M (50 points) = ____2 x 10^{-5} M_______________.

$V_{max,I}$ (50 points) = ____1.5 µmol/min__________________________

The Michaelis constant is:

$$V = \frac{[S]V_{max}}{K_M + [S]}$$

$$K_M = \left(\frac{V_{max}}{V} - 1\right)[S]$$

$$= (3 - 1)10^{-5}\ M$$

$$= 2 \times 10^{-5}\ M$$

In the presence of an inhibitor we have:

$$K_a = \frac{[EI]}{[E][I]} \text{ is the inverse of } K_I \text{ so } K_I = 10^{-6}$$

$$V_I = \frac{[S]V_{max}}{\alpha(K_M + [S])} \text{ so } V_{max,I} = \frac{V_{max}}{\alpha}$$

$$\alpha = 1 + \frac{[I]}{K_I} = 1 + \frac{10^{-3}}{10^{-6}} = 1001$$

$$V_{max,I} = \frac{V_{max}}{\alpha} = \frac{1.5\ mmol/\min}{1001} \approx 1.5\ mmol/\min$$

2. The rate constant for the folding of the villin headpiece is $k = 3 \times 10^5\ s^{-1}$ at 290 K and $9 \times 10^5\ s^{-1}$ at 310 K. Determine that activation energy for the folding transition.

Solution: Use the Arrhenius equation.

$$\ln k_2 - \ln k_1 = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$E_a = \frac{R\ln\left(\frac{k_2}{k_1}\right)}{\left(\frac{1}{T_1} - \frac{1}{T_2}\right)} = \frac{RT_1T_2\ln\left(\frac{k_2}{k_1}\right)}{\left(T_2 - T_1\right)}$$

Plugging in numbers we obtain:

$$E_a = \frac{(8.31\ J/mol\text{–}K)(290\ K)(310\ K)\ln\left(\frac{9 \times 10^5}{3 \times 10^5}\right)}{20\ K} = 41\ kJ/mol$$

E_a (10 points) = ________41 kJ/mol__________________________.