Homework #1

Due: Oct 05, 23:59

1. Derive an equation that describes the rate of an enzyme reaction (v) under uncompetitive inhibition as a function of v_m, K_M, $[S]$, $[I]$, and K_I' where

   v_M = maximum enzyme reaction rate under no inhibition

   K_M = half-velocity constant under no inhibition

   $[S]$ = substrate concentration

   $[I]$ = uncompetitive inhibitor concentration

   $K_I' = k_{-4}/k_4$, where k_4 and k_{-4} are forward and backward reaction rate constants for the formation of the enzyme-substrate-inhibitor complex (ESI) from the enzyme-substrate complex (ES) and uncompetitive inhibitor (I), as illustrated in the following.

   $$ES + I \underset{k_{-4}}{\overset{k_4}{\rightleftharpoons}} ESI$$

   Use the equation you derived to explain how the maximum enzyme reaction rate and half-velocity constant changes due to the presence of an uncompetitive inhibitor.

(50 points)

2. You want to develop an eco-friendly and cost-effective process for removal of nitrate (NO_3^-) from groundwater. Your plan is to supply molasses, a byproduct of sugar manufacturing, as an e^- donor to enhance denitrification in groundwater. Assuming that the molecular formular of molasses can be represented by $C_{12}H_{22}O_{11}$ (same as that for

sugar), answer the following.

1) Write the electron donor half reaction, R_d, in an electron-equivalent form. Use HCO_3^- as an only form of an oxidized carbon species. (15 points)

2) Write the energy reaction, R_e, in an electron-equivalent form. How much grams of molasses are needed per g of NO_3-N consumed for the energy reaction? (15 points)

3) Write the cell formation half reaction, R_c, in an electron-equivalent form. Use the cell formula of $C_5H_7O_2N$ and NO_3^- as a source of nitrogen (not NH_4^+). Also use HCO_3^- as an only form of oxidized carbon species. (15 points)

4) Write the overall cell synthesis reaction, R_s, in an electron-equivalent form. Use the R_d derived from 1) and the R_c derived from 3). How much grams of molasses are needed per g of NO_3-N consumed for the cell synthesis reaction? (15 points)

5) From the calculations you did for 2) and 4), which growth state do you think is more favorable for efficient use of molasses? (A) a rapidly growing state or (B) a slowly growing state? Briefly describe the reason for your selection. (10 points)

6) You are planning to control the molasses supply rate and other environmental conditions relevant to the bacterial growth such that a f_s value of 0.05 is achieved. Write the stoichiometry of the overall reaction occurring at this condition. For 1 g of NO_3-N consumption, i) how much molasses will be consumed (in g molasses), ii) how much alkalinity will be produced (in g as $CaCO_3$), and iii) how much biomass will be produced (in g biomass)? (30 points)