

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

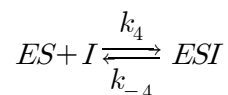
v_m = maximum enzyme reaction rate under no inhibition

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.



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 formula of molasses can be represented by $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ (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 $\text{NO}_3\text{-N}$ 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 $\text{C}_5\text{H}_7\text{O}_2\text{N}$ 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 $\text{NO}_3\text{-N}$ 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 $\text{NO}_3\text{-N}$ 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)