Homework #2

due: October 16, in class

*** Answer the following questions. Be sure to clearly show the procedures to solve the problems.**

1. 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. (20 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? (20 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 an oxidized carbon species. (20 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? (20 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)

2. At the following conditions, at what O_2 partial pressure will an energy reaction using ferric ion (Fe^{3+}) as an e^- acceptor be more thermodynamically favorable than an energy reaction using O_2 as an e^- acceptor? From your results, briefly discuss about the condition where ferric ion reduction will be favorable.

$pH = 8.0$ $T = 20^oC$

$[Fe^{2+}] = 8.0 \times 10^{-4}\ M$ (dissolved at the solubility limit of $Fe(OH)_2$ at pH=8.0)

$[Fe^{3+}] = 4.0 \times 10^{-20}\ M$ (dissolved at the solubility limit of $Fe(OH)_3$ at pH=8.0)

(40 points)