Homework #3

Due: June 02, 2016 (Thu), in class

1 You set up an experiment to determine the overall mass transfer coefficient, K_L for gas-liquid transfer of oxygen and ethanol in a well-mixed reactor. The results of the experiment, the unitless Henry's law constants, and the diffusion coefficients in water are as follows:

Compounds	K_L (m/s)	H_u	D_w (m^2/s)
Oxygen, O_2	2.0×10^{-5}	30	2.1×10^{-9}
Ethanol, C_2H_5OH	4.1×10^{-7}	2.7×10^{-4}	1.2×10^{-9}

Using the ratio of mass transfer coefficients in gas and liquid phase of 100 (i.e., k_G/k_L = 100), answer the following questions.

i) For oxygen and ethanol, determine whether gas or liquid phase will control the mass transfer. Show your reasoning. (10 points)

ii) From the conclusion above, determine the liquid film thickness. (5 points)

2. An advanced oxidation processes is operated in a steady-state, continuously-stirred tank reactor with a hydraulic retention time of 1 min to remove n-dimethylnitrosanmine (NDMA). Determine the hydroxyl radical concentration that should be maintained in the reactor to achieve 95% removal of NDMA by the reactor. The 2^{nd} order rate constant for the reaction of hydroxyl radical with NDMA is 4.0×10^8 L/mole-s.

(20 points)

3. Briefly (in one or two paragraphs for each) describe the following two biological treatment processes for wastewater treatment: i) rotating biological contactor (RBC) and ii) upflow anaerobic sludge blanket (UASB).

(15 points)

4. A CSTR without solids recycle is used to treat a wastewater containing 100 mg/L phenol at 20℃. Using the following kinetic coefficients at 20℃, determine i) the minimal hydraulic retention time (HRT) in days at which the biomass can be washed out faster than they can grow, ii) the minimum HRT at 10℃, assuming the temperature coefficient θ is 1.07 for k and 1.04 for b, iii) the effluent phenol and biomass concentration at an HRT of 7.0 d at 20℃.

$k = 0.80\ g\ phenol/g\ VSS/d$

$K_s = 0.15\ mg\ phenol/L$

$Y = 0.45\ g\ VSS/g\ phenol$

$b = 0.08\ /d$

Hint 1: When there's no solids recycle, SRT should be the same as HRT.

Hint 2: The modified van't Hoff-Arrhenius relationship, $k_2/k_1 = \theta^{(T_2 - T_1)}$, applies to both k and b. Assume Y and K_s are not functions of temperature.

(30 points)

5. A complete-mix activated sludge process with secondary clarification and sludge recycle is used to treat a wastewater at a flowrate of 1,000 m^3/d with a bsCOD of 2,000 mg/L. The MLSS concentration is 3,300 mg/L, MLVSS/MLSS ratio is 0.80, effluent TSS concentration is 20 mg/L, HRT is 24 h, recycle MLSS concentration is 10,000 mg/L, and waste sludge flowrate is 85.5 m^3/d. Using the given information, determine i) the system SRT, ii) the F/M ratio in g bsCOD/g VSS/d, iii) the observed yield in g TSS/g bsCOD, and iv) the true yield in g VSS/g bsCOD. Assume that the effluent bsCOD concentration is negligible compared to the influent concentration, and influent nbVSS is negligible. Use the following parameters.

$$b = 0.10\ g\ VSS/g\ VSS/d$$

$$f_d = 0.15\ g\ VSS/g\ VSS$$

(40 points)

5. The overall reaction for denitrification using methanol as an electron donor is written as below. As can be seen by the reaction, nitrate is used not only as an electron acceptor but also as a source of nitrogen for cell synthesis. Using the reaction stoichiometry, calculate the amount of nitrogen consumed by i) assimilatory nitrate reduction and ii) dissimilatory nitrate reduction as g NO_3-N/g COD.

$$0.1667CH_3OH + 0.1561NO_3^- + 0.1561H^+ \rightarrow 0.00954C_5H_7O_2N + 0.0733N_2 + 0.3781H_2O + 0.119CO_2$$

Hint: Use the following reaction for the aerobic oxidation of methanol:

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$$

(20 points)

6. The following compounds, although not mentioned in the class, have recently been identified to occur in wastewater and natural water bodies, and may cause concerns in human health or aquatic ecosystem. These compounds are referred to as “emerging contaminants” (and there are many, many more examples). From literature search, identify the major uses of each (or each group) of the compounds.

   i) triclosan

   ii) ibuprofen

   iii) bisphenol A

   iv) perfluorochemicals (PFCs)

(20 points)