Homework #4

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

A chemostat having V = 2,000 m^3 receives a flow rate of Q = 1,000 m^3/d of wastewater containing S^0 = 500 mg BOD_L/L. Also included in the wastewater is the inert biomass X_i^0 = 50 mg VSS/L. The following parameters are found for aerobic biodegradation:

$\hat{q} = 20\ g\ BOD_L/g\ VSS_a - d$
$Y = 0.42\ g\ VSS_a/g\ BOD_L$
$K = 20\ mg\ BOD_L/L$
$b = 0.15/d$
$f_d = 0.8$
$k_1 = 0.12\ g\ COD_p/g\ BOD_L$
$k_2 = 0.09\ g\ COD_p/g\ VSS_a - d$
$\hat{q}_{UAP} = 1.8\ g\ COD_p/g\ VSS_a - d$
$K_{UAP} = 100\ mg\ COD_p/L$
$\hat{q}_{BAP} = 0.1\ g\ COD_p/g\ VSS_a - d$
$K_{BAP} = 85\ mg\ COD_p/L$

1. Calculate $S_{\min}$, $\theta_x^{\min}$ and θ_x of the chemostat. (10 points)

2. Calculate effluent VSS, COD and BOD_L. (30 points)

3. Calculate the effluent N and P concentrations when influent concentrations are 50 mg NH_4-N/L and 10 mg PO_4-P/L, respectively. (20 points)

4. Calculate the amount of O_2 that should be supplied to the reactor when influent and effluent DO are 6 and 2 mg/L, respectively. (20 points)

5. Assuming that the influent also contains biodegradable particulate organic matter with a concentration of 100 mg $COD/_L$ and the hydrolysis rate coefficient is k_{hyd} = 0.2/d, recalculate the effluent VSS, COD, and BOD_L. (30 points)

Hints:

- Effluent VSS should include both active and inert biomass, and particulate organic matter supplied from the influent (if there is any)
  ($X_v = X_a + X_i + S_p$ in VSS)
  (for COD→VSS conversion of S_p, assume S_p has a chemical formula similar to biomass)

- Effluent COD should include COD of the substrate, SMP, and VSS
  (eff. COD = substrate COD + SMP COD + VSS COD)
  · Conversion needed for VSS: recall 1.42 g COD/g VSS for biomass ($C_5H_7O_2N$)

- BOD_L stands for "ultimate BOD", the oxygen demand for all biodegradable organic matter
  · S^0 is given as "BOD_L/L", so substrate is assumed to be fully biodegradable
  · SMP is fully biodegradable
  · active biomass is partially biodegradable (biodegradable fraction = f_d)
  · inert biomass is non-biodegradable
  So: eff. BOD_L
  = substrate BOD_L (=COD) + SMP BOD_L (=COD) + f_d × active biomass COD