

**Seoul National University**  
**457.621.001**  
**Biological Processes in Environmental Engineering**

***FINAL EXAMINATION***

**TIME ALLOWED: 80 MINUTES**

**November 29, 2016**

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1. Students may use two double-sided, A4 notes prepared in their own handwriting. Mechanical or electronic reproduction of any notes are not allowed.
2. Students should bring their own calculator which is not pre-programmed with formulae from the class.
3. Be aware that the cheated student will get 80% of the lowest score in class! There is no tolerance at all.
4. Make sure your answers include units if appropriate. Watch your units! Prepare your answers in a logical, easy-to-follow format.
5. This exam contains 5 questions. Each full question is worth 15 to 30 points. Total points = 100.

Use following values for physical constants and properties, if needed:

Atomic weights: C, 12; H, 1; N, 14; O, 16

Ideal gas constant,  $R = 8.314 \times 10^{-3}$  kJ/mole-K

1. Mark true or false (T/F) for the following statements.

Note: This is a bet! +2.5 points for correct answers, -2.5 points for incorrect answers, and 0 point if you choose not to answer.

- i) According to the current method of classification based on phylogeny, bacteria and archaea belong to the same domain of life.
- ii) The net effect of competitive inhibition is an increase in the Michaelis constant,  $K_M$ , while not affecting the maximum rate of an enzyme reaction,  $v_m$ .
- iii) By irreversible inhibition,  $v_m$  will be reduced.
- iv) A process of horizontal gene transfer via a plasmid from one bacterial cell to another is called as transformation.
- v) Gram positive bacteria possess thicker peptidoglycan layer than the Gram negative ones.
- vi) If a reaction is at second order, a PFR (plug flow reactor) shows better performance than a CSTR (continuously stirred tank reactor).
- vii) The substrate utilization rate ( $r_{su}$ ) described by Monod kinetics is not a function of substrate concentration if the substrate concentration is sufficiently higher than the half saturation coefficient  $K$ .
- viii) Soluble microbial products (SMPs) are generally assumed as biodegradable.
- ix) The overall substrate utilization rate of a fully penetrated biofilm is controlled by the diffusion rate of a substrate.
- x) Settling of biomass is one of the major operational problems in the practical application of secondary treatment.
- xi) Denitrification is an alkalinity consuming process.
- xii) Hydrolysis and methanogenesis are two potentially rate-limiting processes for anaerobic digestion.

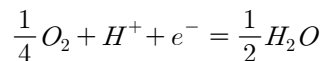


3. *Nitrobacter* is a well-known genus of nitrite-oxidizing bacteria. Answer the following questions.

i) Classify *Nitrobacter* based on the carbon source (autotroph or heterotroph) and the energy source (phototroph, chemolithotroph, or chemoorganotroph). (4 points)

ii) Write the electron donor half reaction ( $R_d$ ) written as an electron equivalent form for this bacterial genus. (6 points)

iii) The electron acceptor half reaction ( $R_a$ ) for *Nitrobacter* is given as follows:



Write the energy reaction ( $R_e$ ) for *Nitrobacter*. (5 points)

4. An activated sludge process receives an influent with 150 mg  $BOD_L/L$  as soluble organics and 10 mg VSS/L as inert biomass at a flowrate of 4000 m<sup>3</sup>/day. Using the following microbial growth parameters, answer the following.

$$\hat{q} = 6.5 \text{ mg } BOD_L / \text{mg VSS} \cdot d$$

$$Y = 0.4 \text{ mg VSS} / \text{mg } BOD_L$$

$$K = 30 \text{ mg } BOD_L / L$$

$$b = 0.05 / d$$

$$f_d = 0.8$$

Neglect the production of soluble microbial products and hydrolysis of particulate BOD/COD.

- i) Calculate the solids retention time (SRT) to achieve the effluent  $BOD_L$  standard of 10 mg/L. (8 points)
- ii) Calculate the daily production of sludge as VSS (i.e.,  $P_{X,VSS}$ ) in kg VSS/d. (7 points)

5. A wastewater with soluble organic concentration of 200 mg  $BOD_L/L$ , dissolved oxygen (DO) concentration of 3.0 mg/L, and a flowrate of  $10^4$  m<sup>3</sup>/day is being treated in an activated sludge process maintained at a solids retention time (SRT) of 6 days. Using the following growth parameters, answer the followings.

$$\hat{q} = 10 \text{ mg } BOD_L / \text{mg VSS} \cdot d$$

$$Y = 0.5 \text{ mg VSS} / \text{mg } BOD_L$$

$$K = 50 \text{ mg } BOD_L / L$$

$$b = 0.05 / d$$

$$f_d = 0.8$$

Neglect the production of soluble microbial products, hydrolysis of particulate BOD/COD, and any inert VSS in the influent.

- i) Calculate the soluble organic concentration of the effluent and the total VSS concentration in the aeration tank of the process. (6 points)
- ii) Calculate the requirement for oxygen supply in kg/day to maintain the DO level in the aeration tank as 2.0 mg/L. Use the cell COD value of 1.42 mg COD/mg VSS. (9 points)