

**NATIONAL EXAMINATION, DECEMBER 2011**

**04-ENV-A4-Water and Wastewater Engineering**

**3 hours duration**

**Notes:**

1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a closed book exam. However, one aid sheet is allowed written on both sides.
3. A Casio or Sharp approved calculator is permitted.
4. Attempt any two questions from Part A, and any two questions from Part B.
5. Marks of all questions are indicated at the end of each question.
6. Clarity and organization of answers are important.

PART A (Total 50 marks)

A1 (25 marks)

- i. Explain mathematically that the settling of discrete particle in a primary sedimentation tank is a function of the surface area and not the depth of the tank. **(15 marks)**
- ii. Explain the phenomenon of coagulation and flocculation of colloidal particles in water treatment. Using the concept of ionic layer theory, explain the mechanisms of “adsorption and charge neutralization” and “ionic layer suppression” in coagulation. **(10)**

A2 (25 marks)

- i. What do you understand by combined residual chlorine, free residual chlorine and chlorine demand? **(10 marks)**
- ii. Explain the phenomenon of break point chlorination with the help of a chlorine dosage vs. residual chlorine curve. **(15 marks)**

A3 (25 marks)

- i. Calculate the hydrated lime (95%) and soda ash required to reduce the hardness of water with following analysis to 50 mg/L, by excess-lime-soda process:

Total hardness	250 mg CaCO <sub>3</sub> /L
Mg <sup>++</sup>	20 mg/L
Alkalinity	200 mg/L as CaCO <sub>3</sub>
CO <sub>2</sub>	6 mg/L

PART B (Total 50 marks)

B1 (25 marks)

- i. Define COD and explain how it differs from BOD? List advantages and disadvantages of COD over BOD. **(7 marks)**
- ii. The 5 day BOD (at 20°C) of a wastewater sample is 200 mg/L, and is 67% of the ultimate BOD. Find 4 day BOD of the sample at 30°C. Assume reaction rate constant  $k$  value (base e) of  $0.20\text{d}^{-1}$ . **(8 marks)**
- iii. Define sludge volume index. The aeration Tank in an activated sludge system is operated at a mixed liquor concentration of 2,500 mg/L. In a settling test, the suspended solids in the mixed liquor were observed to occupy a volume of 300. Calculate the sludge volume index of the mixed liquor. What is your observation about the settleability of this sludge? **(10 marks)**

B2 (25 marks)

An activated sludge system treats a wastewater flow of  $30,000\text{ m}^3/\text{d}$ . The  $\text{BOD}_5$  of the settled wastewater received by aeration tank is 200 mg/L. The operating parameters of the system are as follows:

- a. Aeration tank volume =  $8,000\text{ m}^3$
- b. VSS yield =  $0.65\text{ kg VSS/ kg BOD}_5$
- c. % VSS in mixed liquor TSS = 70%
- d. Mixed liquor MLSS =  $2,700\text{ mg/L}$
- e. Volume of secondary clarifier =  $3500\text{ m}^3$
- f. Depth of secondary clarifier = 3.5 m
- g. Secondary clarifier underflow sludge concentration =  $6,000\text{ mg/L}$

Determine the following:

1. SRT of the system **(6 marks)**
2. Waste activated sludge volume per day **(6 marks)**
3. Return activated sludge flow rate **(7 marks)**
4. Secondary clarifier surface loading rate and solids loading rate. Give your comments about clarifier size under current loading conditions. **(6 marks)**

B3 (25 marks)

- i. An extended aeration system treats a wastewater flow of  $10,000\text{ m}^3/\text{d}$ . The influent  $\text{BOD}_5$  and TKN of the wastewater are 200mg/L and 30 mg/L respectively. The average effluent soluble  $\text{BOD}_5$  and ammonia nitrogen are 3 mg/L and 1 mg/L respectively. Assuming an overall observed biomass yield of  $0.5\text{ kg/kg BOD}_5$ , calculate the oxygen requirement of the system in kg/d. Make suitable assumptions for any missing data.