

NATIONAL EXAMINATION, DECEMBER 2012

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. An 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 principal of ozonation for disinfection of water. Give two advantages and two disadvantages of ozonation over chlorination for disinfection **(10)**

A2 (25 marks)

- i. Describe in detail the Jar test for determining the optimum coagulant dose in water treatment? **(10 marks)**
- ii. With the help of a general chlorination curve, explain the following
 - a. Chlorine demand **(5 marks)**
 - b. Formation of chloramines and organochlorines **(5 marks)**
 - c. Breakpoint chlorination **(5 marks)**

A3 (25 marks)

Define and explain the following terms in water quality and treatment:

- i. Hardness **(5 marks)**
- ii. Taste and odour **(5 marks)**
- iii. Shmutzdecke or dirty skin in rapid sand filtration **(5 marks)**
- iv. Charge neutralization and ionic layer compression in coagulation **(5 marks)**
- v. Discrete and flocculent settling **(5 marks)**

PART B (Total 50 marks)

B1 (25 marks)

- i. Define and differentiate between
 - a. $cBOD_5$, BOD_5 and ultimate BOD (6 marks)
 - b. COD, biodegradable COD, and readily biodegradable COD (6 marks)
 - c. Total Nitrogen, TKN and Ammonia-Nitrogen (7 marks)
 - d. Organic loading rate and Solids loading rate (6 marks)

B2 (25 marks)

An activated sludge system treating a wastewater flow of $10,000 \text{ m}^3/\text{d}$ has the following primary effluent characteristics:

- a. $BOD_5 = 150 \text{ mg/L}$
 - b. $TKN = 50 \text{ mg/L}$
 - c. Alkalinity = 200 mg/L
- I. For a VSS yield of $0.65 \text{ kg VSS/kg BOD}_5$, calculate the volume of waste activated sludge per day for a secondary clarifier underflow sludge concentration of $8,000 \text{ mg/L}$ (13 marks)
 - II. If 80% TKN is nitrified, and a minimum of 50 mg/L of alkalinity is to be maintained in the final effluent, calculate the additional alkalinity required in kg/d . Assume each kg of TKN requires 7 kg of alkalinity for nitrification. (12 marks)

B3 (25 marks)

- i. Define sludge volume index. The aeration tank in an activated sludge system is operated at a mixed liquor concentration of $2,500 \text{ mg/L}$. In a settling test, the suspended solids in the mixed liquor were observed to occupy a volume of 300 mL . Calculate the sludge volume index of the mixed liquor. Give your comments on the settleability of this sludge? (10 marks)
- ii. Calculate the surface overflow rate (SOR) and solids loading rate (SLR) for a secondary clarifier for the following operational parameters of an activated sludge process. Also, assuming that the secondary sludge has typical settling characteristics of a well settling sludge, comment on the values of SOR and SLR in terms clarifier's ability to comply with effluent TSS requirement of 20 mg/L (15marks)
 - a. Mixed liquor flow = $5000 \text{ m}^3/\text{d}$
 - b. Return activated sludge flow = $5000 \text{ m}^3/\text{d}$
 - c. Mixed liquor MLSS = 3000 mg/L
 - d. Secondary clarifier volume = 1200 m^3
 - e. Secondary clarifier depth = 4 m