

**National Examination May 2011**

**04-Env-A4, Water and Wastewater Engineering**

**3 hours duration**

**Notes:**

1. If doubt exists 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 an OPEN BOOK EXAM.
3. Any non-communicating calculator is permitted.
4. Answer all questions from PART A and any TWO questions from B1, B2, and B3.
5. Values of all questions are indicated.
6. Clarity and organization of the answer are important.

**PART A (total 50 marks)**

**A1 (20 marks)**

- (i) Compare and contrast water softening and ion exchange in water treatment applications. (10 marks)
- (ii) Write the half reactions for the reduction of Chlorine dioxide ( $\text{ClO}_2$ ) to  $\text{Cl}^-$  and  $\text{Cl}_2$  to  $\text{Cl}^-$ . Based on the half reactions, how many chlorine atoms will be added to water when chlorine dioxide is the disinfecting agent versus chlorine. (10 marks)

**A2 (20 marks)**

- (i) How much alkalinity is consumed in the form of  $\text{CaCO}_3$  is consumed by 50 mg/L of (i)  $\text{FeCl}_3$  and (ii)  $\text{Al}_2(\text{SO}_4)_3 \cdot 14.2 \text{H}_2\text{O}$ . (14 marks)
- (ii) Discuss briefly the advantages of flocculation as means of water or waste water treatment. (6 marks)

**A3 (10 marks)**

What average intensity must be provided in a UV system to achieve 99.99% removal of indicator microorganisms with an inactivation rate constant of  $0.010 \text{ m}^2/\text{J}$  and a detention time of 2 min in the UV zone?

**Part B (50 marks). Answer two of the following three.**

**B1 (25 marks)**

A waste has a COD of 4500 mg/L. The wastewater flow is  $750 \text{ m}^3/\text{d}$  and 70 percent of the waste is anaerobically digested. Calculate the methane generation rate. Also calculate the maximum yield of methane in  $\text{m}^3$  of methane per Kg of COD consumed.

**B2 (25 marks)** The influent of  $10,000 \text{ m}^3/\text{d}$  to a secondary biological reactor has a 5 day BOD of 150 mg/L. It is desired to have an effluent total 5-day BOD of 30 mg/L with a 5 day BOD of microbial cells of 13.8 mg/L, an MLVSS of 3000 mg/L and an underflow concentration of 10,000 mg/L. Use the kinetic parameters as follows:  $Y = 0.57$ ;  $k_d = 0.06$  per day and assume  $\theta_c = 10$  days. What is the volume of the reactor needed. What are the volumes and mass flow rates of sludge wasted per day?.

**B3 (25 marks)**

- (i) What is the lagoon temperature in a 2.7 m deep aerated lagoon with a surface area of 1.1 ha. The lagoon has a detention time of 3 d and influent and ambient temperatures are 15 and 25 deg Celcius respectively.. (10 marks).
- (ii) Calculate the COD of a microorganism with the formula  $\text{C}_{106}\text{H}_{263} \text{O}_{110} \text{N}_{16} \text{P}$  (15 marks).