NATIONAL EXAMINATION, MAY 2012

98-CIV-B5-Water Supply 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 Casio or Sharp 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 the difference between free and combined residual chlorine and compare the relative significance of these two in water treatment practices. **(10 marks)**

ii. An ion exchange process is to treat 25,000 m^3/d of raw water with 300 mg/L of hardness and produce treated water with hardness of no more than 75 mg/L. The adsorptive capacity of the selected medium is 90 kg-hardness/m^3-medium at a flow rate of 0.4 m^3/m^2-min. Determine the volume of media required and number of 2.0 m diameter beds to treat this water. **(15 marks)**

A2 (25 marks)

i. What is aeration used for in water treatment plants and describe briefly how it achieves that. Explain why it is more commonly used in groundwater than surface water. **(10 marks)**

ii. Name and discuss the four mechanisms that are known to occur during coagulation. **(15 marks)**

A3 (25 marks)

i. A city draws its water from a large reservoir which has a turbidity of 30 to 50 NTUs and hardness of 250 mg/L. Refractory organics are not a problem and TDS are low. However, raw water has seasonal taste and odour which are categorized as "fishy" or "musty". Draw a schematic diagram of a treatment plant that will render this water potable. Identify each unit and briefly state its purpose. Show points of chemical addition and identify the chemicals. **(15 marks)**

ii. For a BOD test, thirty (30 mL) of a water sample of DO zero was mixed with 270 mL dilution water of DO 10 mg/L, and put into an incubator at 30°C. The sample was taken out of the incubator after seven days and its DO was found to be 5 mg/L. Assuming a reaction rate constant "K" value of 0.2 at 20°C and $K_T = K_{20}\,(1.05)^{T-20}$, Determine the five day BOD at 20°C. **(10 marks)**

PART B (Total 50 marks)

B1 (25 marks)

i. In a wastewater treatment plant with a peak flow capacity of 40 million litres a day, the coarse screen consists of bars, 9 mm thick and 55 mm deep. If the screen rack is inclined at 60° with the horizontal and the peak flow velocity through the clean screen is 0.8m/s, find the head loss through clean screen and when it is half clogged. **(10 marks)**

ii. What is the general design requirement of a grit removal tank? Explain the difference between the design strategy of a "constant flow through velocity" and an aerated grit tank. What is the function of a proportional flow weir in a grit chamber and explain how it is used to serve that function. **(15 marks)**

B2 (25 marks)

iii. Design a rectangular primary clarification system for a flow of 20,000 m^3/d. Calculate the mass of sludge solids and volume of sludge produced per day. Make suitable assumptions for the influent TSS, primary TSS removal efficiency, primary sludge concentration and specific gravity based on the typical values in a municipal wastewater treatment plant. **(15 marks)**

iv. Explain the phenomenon of biomass sloughing in a trickling filter. Also list the key functions of secondary effluent recirculation in a trickling filter **(10 marks)**

B3 (25 marks)

i. Define sludge volume index (SVI) and explain its significance in monitoring the performance of the treatment process in a wastewater treatment plant. The settled sludge volume of a 1000 mL sample of mixed liquor, after a 30 minute settling period is 800 mL. Find the SVI for the mixed liquor if the mixed liquor MLSS concentration is 2000 mg/L, and comment on the inference you make on the quality of sludge. **(10 marks)**

ii. An operator reports a gradual decline in the pH over a couple of weeks (from a normal average of 7.5 to the current pH of 7.0), and a marked reduction in biogas production in the anaerobic digester at a municipal wastewater treatment plant. It is known that the plant is operating close to its rated capacity and is bound for a major expansion in the near future. Also a major spill was reported by an industry in the city (preceding the digester upset), which found its way the municipal sewer system, and had significant concentration of sulfates and biodegradable organic compounds. Explain the investigative steps to determine the potential causes of this digester process upset with respect to anaerobic digestion mechanism and the potential measures that could be taken to revive the digester process. **(15 marks)**