National Examination December 2008

98-Civ-B5, Water Supply and Wastewater Treatment

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) A 0.65 m deep filter bed has a uniformly sized sand with a diameter of 0.45 mm, specific gravity of 2.65 and a volumetric shape factor of 0.87. If a hydrostatic head of 2.3 m is maintained over the bed, determine the flow rate at 20°C. Assume the porosity is 0.4. **(10 marks)**

(ii) How much alkalinity (as $CaCO_3$) is consumed by a dose of 40 mg/L of each of the following coagulants: $Al_2(SO_4)_3 \cdot 14\ H_2O$; $FeSO_4.7H_2O$; $FeCl_3$; and $Fe(SO_4)_3$? **(10 marks)**

A2 (20 marks)

(i) What are the amounts of chlorine and anhydrous ammonia that must be added to a flow of 22000 m^3/d to achieve a combined residual of 1.0 mg/L Cl_2. Assume no side reactions. **(8 marks)**

(ii) The influent of 10,000 m^3/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 ? **(12 marks)**

A3 A raw water has the following constituents expressed in meq/L: Ca^{2+} 4.6; Mg^{2+} 1.0; Na^{+} 2.1; HCO^{-}_3 2.4; SO_4^{-2} 2.9; Cl^{-} 2.4 and CO_2 0.6. What is the total hardness expressed as $CaCO_3$. **(10 marks)**

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

B1 (25 marks)

(i) A primary wastewater treatment plant providing for separate sludge digestion receives an influent wastewater with an average flow of 2.0 Mgal/d. The suspended solids removed by primary sedimentation are 200 mg/L. Determine the required digester volume given volatile matter in settled solids = 75%; water in untreated sludge = 96%; Specific gravity of mineral solids = 2.60; specific gravity of organic solids = 1.30 and mean cell residence time = 10 days. **(14 marks)**

(ii) Assume that a particle has a constant settling velocity. What is the settling velocity of a particle that has taken 6 h to settle a depth of 3.0 m in an ideal

circular clarifier with a Q/A of 35 $m^3/m^2/d$. The influent flow is distributed uniformly across the plan area of the clarifier and underflow is being removed from the clarifier at a rate of 7.5 $m^3/m^2/d$. **(11 marks)**

B2 (25 marks)

A rectangular clarifier with a length: width ratio of 3:1 receives a flow of 850 m^3/ day. The clarifier's depth is is 4.0 m and the detention time of the water in the clarifier is 2.4 h. what are the surface overflow rate and the horizontal flow through velocity if the flow is distributed uniformly across the cross-sectional area of the tank?

B3 (25 marks)

A waste with a 5-day BOD of 200 mg/L and a rate constant, k_L, of 0.1 day^{-1} is discharged into a river at a rate of 1 m^3/s. Calculate the ultimate BOD of the waste before it is discharged into the river. Assuming instantaneous mixing after discharge, calculate the ultimate BOD of the river after it has received the waste. Assume the river has a flow rate of 9 m^3/ s and an ultimate BOD of 2 mg/L just upstream of the discharge point. Finally calculate the ultimate BOD and the 5 day BOD of the river 50 km downstream of the point of discharge. The river has a width of 20 m and a depth of 5 m.