

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

043



Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: CVX4348 - Water and Wastewater Engineering
Academic Year	: 2022/2023
Date	: 16 th February 2024
Time	: 0930 hrs-1230hrs
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **seven (7)** questions in **six (6)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts / codes / equations are provided in last page
6. This is a Closed Book Test **(CBT)**.
7. Answers should be in clear handwriting.
8. Do not use the red colour pen.

Question 1

(a) Since population is always a relevant factor in estimating future water use, it is necessary to predict, in some manner, what the population will be.

(i) A water treatment plant is generally designed for 30 years period. Why? Explain briefly. [02 marks]

(ii) A growing semi urban community needs a water supply scheme and it was requested to design a scheme with the design period of 3 decades.

The census records for population growth is given as follows. Estimate the population in 2053 and the design flow if the per capita demand is 200lpcd.

Year	1993	2003	2013	2023
Population	2028	5034	8567	11459

[07 marks]

(b) The main function of the intake s is to collect water from the surface source.

(i)What factors to be considered when selecting a location for an intake. List five of them.

[02 marks]

(iii) Classify the intakes. Explain one of them briefly.

[03 marks]

(c) (i) List four pressure driven membrane methods available for advanced water treatment,

[01 marks]

(ii) Briefly explain one of the above methods

[02 marks]

(iii) What are the factors caused for tastes and odours.

[02 marks]

(iv) List three methods that can be employed for removal of taste and odour in the water treatment plants.

[01 marks]

Question 2.

(a) (i) Write the mathematical expressions for overflow rate and weir loading. Mention the denotations that used. [02 marks]

(ii)A residential community has an estimated ultimate population density of 1,000 /km².

The town covers 20Km² and the per capita usage of water is 200lpcd. If the detention time is 1.25 hours, what is the volume of the tank. If depth of the tank is 4 m, estimate the diameter of the tank. How many sedimentation tanks are you going to employed.

For circular sedimentation tanks V is given by $V= D^2 (0.011D + 0.785)$. Find the overflow rate and weir loading.

[06 marks]

- (b) Nearly all water on earth contains naturally occurring fluoride. Investigations of the decay preventing effects of naturally occurring fluoride in water led to the start of community water fluoridization in 1945. Fluorides are effective dramatically reducing tooth decay, particularly for teenagers and adults
- (i) Are there negative effects of fluoridization? [03 marks]
 - (ii) What else may the fluoride added to drinking water do? [02 marks]
 - (iii) Are there alternatives? List them [03 marks]
- (c) A community requires a maximum flow of 50×10^6 L/d water during 12h in a peak day, beginning at 6am and ending at 6pm. During the remaining 12 hours, it needs a flow of 8 million liters per day. During the entire day, the water treatment plant is able to provide a constant flow of 28 million L/d, which is pumped into the distribution system. How large must the elevated storage tank be to meet this peak demand. [04 marks]

Question 3

- (a) (i) List the laboratory tests that are used for testing water quality. [02 marks]
- (ii) The dosage of coagulants depends upon factors including the water quality characteristics of water. List the factors to be considered when selecting a coagulant. [02 marks]
- (iii) A town proposed water works supposed to distribute treated water for the population of Q1 (b) in 2050 design discharge. Assuming the losses and wastages are about 15% estimate the amount of alum needed in Kg/day for the treatment plant if the dosage is 14mg/l. [04 marks]
- (b) (i) Why filtration is needed in water treatment systems? [01 marks]
- (ii) A water treatment system consists of a filtration unit of 8m by 6m. What is the filtration rate if it receives 6 million L/d? [03 marks]
- (iii) What amount of clean water required for backwashing the above filter unit if the back wash rate is $36 \text{ m}^3/\text{hr}/\text{m}^2$? [04 marks]
- (c) (i) Disinfection is important in water treatment systems. What are the methods available for disinfection in water works. [01 marks]
- (ii) In treating $1 \times 10^6 \text{ m}^3$ of water, 100 kg of liquid chlorine are applied. Compute the dosage in milligrams per liter. [03 marks]

Question 4.

- (a) The following data is available regarding various types of area and the corresponding impermeability coefficient of a town:

Type	% Area	Impermeability coefficient
Roofs	15	0.9
Pavements	20	0.8
Lawns, gardens, vegetation	40	0.15
Unpaved	15	0.2
wooded	10	0.05

- (i) Determine the average coefficient of runoff. [03 marks]
- (ii) If the total area of the district is 25 hectares, determine the minimum stormwater runoff for a rainfall intensity of 50mm/hour. Use rational formula $Q=0.278 CIA$. [04 marks]
- (b) (i) Write a note on 'time of concentration' and its significance in determining the storm water flow. [02 marks]
- (iii) For a small town, having projected population of 30,000 residing over an area of 20 hectares, find the discharge for the combined sewer for the following data:
- Rate of water supply = 150 liters per capita per day
Time of concentration (T_c) = 30 minutes
Total rainfall = 40mm during T_c
- { $WWF = [r/6T_c * A] m^3/s$; where r- rainfall (mm); A-Impervious area (ha)} [06 marks]
- (c) (i) What is meant by "self-purification capacity" property of a stream Explain the factors affecting this property. [02 marks]
- (ii) When pollution load is discharged into the DO content of the stream goes on depletion. Explain this phenomenon using 'oxygen sag curve'. Illustrate oxygen sag curve along with the deoxygenation and reoxygenation curves. Use starting time of flow from point of pollution. [03 marks]

Question 5.

- (a) (i) Differentiate between "Oxygen Demand" and "Biochemical oxygen Demand" [02 marks]
- (ii) The BOD_5 of waste is has been measured as 600mg/L. In the above question, if the reaction rate constant is $k = 0.23/\text{day}$, what would be the ultimate BOD of waste? [04 marks]
- (iii) What proportion of BOD_u would remain unoxidized after 20 days? [02 marks]
[$k = k_{20} \vartheta^{(T-20)}$; $BOD_5 = L_0 (1 - e^{-kt})$; $\vartheta = 1.047$]
- (b) A city discharges $1.25 \text{ m}^3/\text{s}$ of wastewater into a stream whose minimum rate of flow is $8 \text{ m}^3/\text{s}$. At this condition, the stream BOD_5 concentration is 6 mg/l and the pollutant at the outfall is 450 mg/l above the outfall. Determine the BOD_5 at the downstream stream of wastewater receiving body. [05 marks]
- (c) (i) What are the advantageous of circular sewer section [01 marks]
- (ii) Enumerate various forces that act on a sewer pipe laid underground. Discuss in detail one of those. [02 marks]
- (iii) Explain the phenomenon of crown corrosion with the help of neat sketch. [03 marks]
- (iv) How can crown corrosion be avoided. [01 marks]

Question 6.

- (a) (i) List the materials that are used for constructing sewers. [02 marks]
- (ii) List five factors to be considered when selecting a particular material of a sewer. [02 marks]
- (iii) A sewer line carrying an average discharge of 200 L/s has a minimum flow of 40% of average flow. Calculate the minimum discharge, design diameter. [03 marks]
- (b) The Secondary treatment include all treatment methods under the biological unit processes. While the basic principals remain unchanged in all secondary treatment processes, the techniques used in their application may vary widely, but can be classified into two mainly.
- (I) What are those two categories. [01 marks]
- (II) Provide three examples for each category. [01 marks]
- (III) Explain the removal mechanism of a treatment system of one of the above category. [04 marks]

- (c) Two proposed rectangular settling basins, each having dimensions of 10 m long, 7 m wide, and 3 m deep, is used for 1500 m³ of water per day. Calculate the detention time, overflow rate and weir loading. [04 marks]

Question 7.

- (a) A cheese processing plant generates 1200 m³/day of wastewater each day. The wastewater is treated in an activated sludge plant. The average BOD₅ of the raw wastewater before primary settling is 1400 mg/l. The aeration tank has effective liquid dimensions of 8.0 m wide by 10.0m long by 4.0 m deep. The plant operating parameters are as follows.

Soluble BOD₅ after primary settling =890 mg/l

BOD₅ of effluent =20mg/l

MLSS=3400 mg/l

Determine the following:

- (i) Aeration period [03 marks]
- (ii) F/M ratio [03 marks]
- (iii) BOD removal efficiency [01 marks]
- (iv) What would be the oxygen requirement per day, if the sludge age is 15 days? The O₂ requirement per day is given as: $1.47 Q (S_0 - S) - 1.42V(x/\theta_c)$ with usual notations. [03 marks]
- (b) (i) List the methods available to reduce the water content of sludge under sludge treatment. [02 marks]
- (ii) In aerobic sludge digestion mixing is important. Why? Briefly explain. [02 marks]
- (c) (i) What is the need of an equalization tank? [01 marks]
- (ii) A treatment plant design for a city requires an equalization basin. The average daily flow rate is 0.5m³/s. If the overflow rate is 30.0 m³/d and detention time is 2.2 h what would be the volume of the primary sedimentation tank. Assume the depth of the basin is 3.5m. If the BOD₅ to the primary sedimentation tank is 400 mg/L, and the BOD₅ removal efficiency is 30%, how many BOD₅ kilograms are removed in the primary sedimentation tank each day [05 marks]

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Supplementary

$$r_u = -\frac{\mu_m SX_{avg}}{K_s + S}$$

$$\frac{1}{\theta_c} = \frac{Y\mu_m(S_o - S)}{(S_o - S) + (1 + \alpha)K_s \ln(S_i/S)} - k_d$$

$$\frac{F}{M} = \frac{QS_0}{VX}$$

$$1.47 Q (S_0 - S) - 1.42 V(x/\theta_c)$$