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The Open University of Sri Lanka

Faculty of Engineering Technology

Department of Civil Engineering

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	: 2024/2025
Date	: 6th March 2026
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 Twenty (20) 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 **[20 Marks]**

(a) Population forecasting is required to estimate future water demand for planning and design.

(i) Define design period and design population in water supply engineering.

(ii) State two reasons why water treatment plants are usually designed for long design periods, but distribution networks may be upgraded in stages.

(iii) A township plans a new water treatment plant with a 30-year design period. Population data is:

Year	1990	2000	2010	2020
Population	3200	5100	7400	10600

Estimate the population in 2050 using a suitable method, and determine the average daily design flow if per capita demand is 220 Lpcd.

(b) An intake structure must ensure reliable withdrawal of water under varying source conditions.

(i) List five operational and water-quality factors that influence intake design (not only location).

(ii) With sketches, differentiate river intake and reservoir intake and explain one advantage and one limitation of either type.

(c) (i) List four pressure-driven membrane processes used in water treatment.

(ii) Explain the working principle of nanofiltration (NF) OR reverse osmosis (RO).

(iii) Give four causes of taste and odour in drinking water (biological/chemical/physical).

(iv) List three practical applications which are used to control taste and odour in water treatment plants.

Question 2 **[20 Marks]**

(a) (i) List four important water-quality parameters tested in the lab that are directly relevant to sedimentation and filtration design.

(iii) A WTP must treat 22 ML/d. Design a circular sedimentation tank for a surface overflow rate of 28 $m^3/m^2 \cdot d$.

If detention time is 2.0 h and side water depth is 3.5 m, determine:

- required surface area
- tank diameter
- tank volume

(b) (i) State two objectives of filtration in drinking-water treatment.
(ii) A rapid gravity filter has plan dimensions 7 m × 5 m. It receives 4.2 million L/d. Find the filtration rate (m/h).
(iii) If the backwash rate is 45 $m^3/h/m^2$ and backwash duration is 7 minutes, determine the backwash water volume per wash.
(iv) Estimate the percentage of daily backwash water quantity out of total treated water per day.

(c) (i) A plant targets 0.5 mg/L free chlorine residual after contact. If chlorine demand is 1.2 mg/L, estimate required applied dose.
(ii) Why is backwashing necessary in rapid sand filters?
(iii) A filter unit has an area of 60 m^2. If it is operated at 6 m/h, find the treated water output in ML/d.
(iii) A plant applies 80 kg/day of chlorine to disinfect 16 ML/d. Compute the dosage in mg/L.

Question 3 **[20 Marks]**

(a) (i) Why is a distribution reservoir necessary for a water distribution system. Briefly explain.
(ii)What are the advantages of gate valves which use for water distribution networks. List three of them.
(iii) To distribute water among consumers a distribution system net work is used. Name four different distribution systems which are designed based on the location of buildings.

(b) (i) List two advantages of using inclined plate (lamella) settlers.
(iii) A rectangular clarifier is designed for flow 30 ML/d and overflow rate 32 $m^3/m^2 \cdot d$. Assume L:W = 4:1 and depth = 3.0 m. Determine the required length and width, and the volume.

(c) (i) A city water treatment plant needed to treat 24 ML/d. 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.
(ii)Activated carbon is commonly used as an advanced treatment step. State two locations in a Water Treatment Plant where PAC dosing may be applied and why.

Question 4. **[20 Marks]**

(a) (i) What is the consequence of underestimating Tc in storm sewer design?

(ii) A road drainage catchment has A = 0.8 km^2, C = 0.80, and rainfall intensity I = 90 mm/h. Compute peak runoff using Rational Method.

(iii) A pipe of 600 mm diameter is laid at a slope that gives full-flow velocity 1.6 m/s. Check whether this pipe can carry the computed flow at full flow.

(b) A catchment has the following land-use distribution:

Type	% Area	Runoff coefficient (C)
Roofs	18	0.90
Roads/Pavements	22	0.85
Lawns/Parks	35	0.20
Compacted soil	15	0.35
Wooded area	10	0.10

(i) Determine the weighted average runoff coefficient for the catchment.

(ii) If the catchment area is 30 ha and rainfall intensity is 65 mm/h, compute peak runoff using Rational formula Q = 0.278 C I A (Q in m^3/s, I in mm/h, A in km^2).

(c) (i) What happens to DO immediately after a discharge point, and why can DO recover downstream?

(ii) Draw a labelled oxygen sag curve using time from discharge point on the x-axis. Show the critical point and explain its significance.

(iii) List four mechanisms contributing to river self-purification (physical/chemical/biological).

Question 5 **[20 Marks]**

(a) (i) Explain crown corrosion in sewers (mechanism) with a neat sketch.

(ii) List four methods to prevent or reduce crown corrosion.

(iii) Why is ventilation important in large sewer systems?

(b) (i) Compare Activated Sludge and Trickling Filters in terms of: land requirement, energy use, process stability (any three).

(ii)The BOD_5 of waste is has been measured as 200mg/L. If the reaction rate constant is k=0.21/day, what would be the ultimate BOD of waste?

(c) Two circular secondary clarifiers are proposed, each of diameter 12 m and water depth 3.0 m, treating 2400 m^3/day. Calculate,

- Detention time,
- Surface overflow rate,
- Weir loading if each tank has a peripheral weir.

Question 6 **[20 Marks]**

(a) (i) List four forces/loads acting on an underground sewer pipe.
(ii) Explain any one of the above loads in detail and how it influences design.
(iii) Define self-cleansing velocity and state two typical problems caused when it is not achieved.

(b) A food processing factory discharges 1500 m^3/day. After equalization and primary settling, the BOD_5 entering aeration is (S_0=780) mg/L. Effluent BOD_5 is (S=35) mg/L.
Aeration tank = 10 m × 8 m × 4.5 m. MLSS (X = 3600) mg/L. Sludge age θc = 18) days.
Determine:
(i) Aeration period HRT in hours
(ii) F/M ratio
(iii) BOD removal efficiency across biological treatment
(iv) Oxygen requirement per day

(c) (i)An aeration tank treats 6000 m^3/day of wastewater with influent BOD_5 = 220 mg/L.
Tank volume = 1800 m^3, MLSS = 3000 mg/L.
Calculate F/M ratio.
(ii) Briefly discuss how changing F/M, affects sludge settleability and effluent quality.

Question 7 **[20 Marks]**

(a) (i) What is meant by sludge bulking? State two causes.
(ii) Explain the significance of:

- F/M ratio
- SRT (sludge age)
- DO concentration
- MLSS/MLVSS

in controlling performance and preventing sludge bulking.

(b) (i) Differentiate between aerobic and anaerobic digestion.
(ii) List three benefits of equalization for industrial wastewater (flow + quality).
(iii) Why is pH control important before biological treatment? Mention two impacts of improper pH.

(c) Primary clarifier design: overflow rate + weir loading
A treatment plant handles 15,000 m^3/day. Two rectangular primary clarifiers are planned in parallel.
Design criteria:

- Surface overflow rate = 35 $m^3/m^2 \cdot day$
- Detention time = 2.5 h
- Depth = 3.5 m
- Each tank provides two end weirs, each equal to tank width
- Assume L:W = 5:1

Determine:
(i) Total surface area required and area per tank
(ii) Dimensions (L and W) of each tank
(iii) Detention time
(iv) Weir loading rate

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Supplementary

$k=k_{20}\vartheta^{(T-20)}$; $BOD_5 = Lo\,(1-e^{-kt})$; $\vartheta = 1.047$

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

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

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

Oxygen requirement =1.47 Q (S_0-S) - 1.42V(x/θ_c)