



UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION MAY 2024 SEMESTER

COURSE : CEB4223 - INDUSTRIAL EFFLUENT ENGINEERING
DATE : 1 AUGUST 2024 (THURSDAY)
TIME : 9.00 AM - 12.00 NOON (3 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

- i. There are **SIX (6)** pages in this Question Booklet including the cover page and appendix.
- ii. **DOUBLE-SIDED** Question Booklet.
- iii. **Graph papers will be provided.**

1. As an environmental engineer, your task is to design the sedimentation tank for the primary treatment process of Segari Wastewater Treatment plant. The data is given in **TABLE Q1**.

TABLE Q1: Data of particles and fluid

Particle density, ρ_p	1400 kg/m ³
Temperature of water, T	20°C
Water density, ρ_f	998.2 kg/m ³
Viscosity, μ_f	0.001 kg/m·s
Flow rate, Q	7500 m ³ /d

- a. Evaluate the particle size that would be removed and may be scoured for the diameter range between 0.010 mm – 0.060 mm in the sedimentation tank.

[10 marks]

- b. Design the clarifier if the particles of the size calculated in **part (a)** be completely removed from a rectangular type of clarifier.

[15 marks]

2. A thickening process takes place in a settling tank of secondary clarifier for activated sludge with incoming flowrate, Q , and suspended solid concentration, C_o , of 4000 m³/d and 2500 mg/L, respectively. The target of the secondary clarifier is to yield a thickened solid concentration, C_u , of 9,000 mg/L. **TABLE Q2** shows the experimental data obtained from settling test.

TABLE Q2: Data for settling curve.

Interface height (m)	Time (min)
5.0	0
4.4	1
4.0	2
3.7	3
3.45	4
3.2	5
2.5	10
2.0	15
1.6	20
1.4	25
1.3	30
1.2	45

- a. Evaluate the area required for thickening and clarification to determine the controlling area for settling at the clarifier.

[15 marks]

- b. Determine the solid loading and hydraulic loading rate.

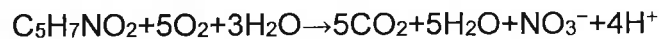
[10 marks]

3. The secondary treatment plant employs the aerobic complete-mix biological treatment process, which operates without recycle stream to treat wastewater with the following characteristics as in **TABLE Q3**:

TABLE Q3: Wastewater characteristics

Biodegradable soluble chemical oxygen demand (COD) concentration:	500 g/m ³
Wastewater flow rate:	1000 m ³ /day

The reactor effluent contains 10 g/m³ of COD concentration and 200 g/m³ of volatile suspended solids (VSS) concentration.



- a. Describe the purpose of the biological treatment process. [3 marks]
- b. Evaluate the effectiveness of the biological treatment process by comparing the theoretical expectations with the actual performance system to comprehensively assess the treatment efficiency. [10 marks]
- c. Understanding the stoichiometry of the microbial growth process, determine the biomass yield, Y , in g VSS/g COD removed. [7 marks]
- d. Analyze the amount of VSS produced daily in the reactor. Comment on the overall performance of the aerobic treatment process. [5 marks]

4. Water use data for a four-operation process are given in **TABLE Q4**. Based on the data provided, the minimum water consumption is to be achieved for the plant system that involving the four operations, and maximum of water reuse.

TABLE Q4: Water Use Data

Operation	Contaminant mass, g/hr	C_{in} , ppm	C_{out} , ppm	Limiting water flowrate, t/hr
1	2,000	0	100	20
2	5,000	50	100	100
3	30,000	50	800	40
4	4,000	400	800	10

- a. Draw the limiting composite curve along with the maximum water target. [10 marks]
- b. Construct the design grid and a complete network design. [8 marks]
- c. Propose a water network for the four operations and justify your answer. [7 marks]

- END OF PAPER-

APPENDIX: List of Equations

Stoke's Law for terminal settling velocity, $v_t = \frac{(\rho_p - \rho_f)gd^2}{18\mu}$

Scouring velocity: $v_h = \sqrt{\frac{8k(s-1)gd}{f}}$,

$k = 0.04$ for unigranular sand and 0.06 sticky, interlocking matter

$f = 0.02 - 0.03$ (Darcy-Weisbach friction factor)

Flow rate, $Q = Av_c = A \times \text{Overflow rate [in } m^3/m^2 \cdot \text{day]}$

$$H_u = \frac{C_o H_o}{C_u}$$

$$A = \frac{Qt_u}{H_o}$$

$$\text{COD removal Efficiency (\%)} = \frac{\text{COD}_{\text{Influence}} - \text{COD}_{\text{Effluent}}}{\text{COD}_{\text{Influence}}} \times 100$$

$$V_{SS \text{ produced/day}} = Q \times V_{SS \text{ Effluent}}$$

$$m_w = \frac{\Delta m_c}{\Delta C}$$