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, Co, of 4000 m^3/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/m^3 of COD concentration and 200 g/m^3 of volatile suspended solids (VSS) concentration.

$$C_5H_7NO_2 + 5O_2 + 3H_2O \rightarrow 5CO_2 + 5H_2O + NO_3^- + 4H^+$$

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, $v_t = \frac{(\rho_p - \rho_f) g d^2}{18\mu}$

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, $Q = Av_c = A \, x \, Overflow\ rate\ [in\ m^3/m^2.day]$

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

$$A = \frac{Q t_u}{H_o}$$

COD removal Efficiency (%) = $\frac{COD_{Influence} - COD_{Effluent}}{COD_{Influence}} X\ 100$

$V_{SS\ produced}$/day = $Q \, x \, V_{SS\ Effluent}$

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