UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
SEPTEMBER 2015 SEMESTER

COURSE	**:**	**CCB4233 – INDUSTRIAL EFFLUENT ENGINEERING**
DATE	**:**	**7th JANUARY 2016 (THURSDAY)**
TIME	**:**	**9.00 AM – 12.00 NOON (3 hours)**

INSTRUCTIONS TO CANDIDATES

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

Note :
- i. There are **SEVEN (7)** pages in this Question Booklet including the cover page and **APPENDIX**.
- ii. Graph Paper will be provided.

1. a. The BOD data given in **TABLE Q1a** shows a series of tests on a 24-hr composite effluent from an effluent treatment plant. The samples were collected before the chlorination, so seeding was not necessary.

TABLE Q1a: BOD data

Time, Days	1	2	3	5	6	9	13	17
BOD, mg/L	4	6.3	12.5	13.6	14.3	18.2	20.2	23.8

i. Determine the 5-day BOD value by using a plot.

[4 marks]

ii. Using another plot of $(\text{time/BOD})^{1/3}$, estimate the k-rate if $k = 2.61(A/B)$, where A is the slope and B is the intercept of the plot.

[6 marks]

b. The data for two wastewater samples is shown in **Table Q1b**. Evaluate the total quantity of oxygen that must be furnished to stabilize completely each of the wastewater, and the corresponding COD and ThOD. Comment on your results. State any assumptions that you have made in the evaluation.

TABLE Q1b: Wastewater Sample Data

Item	BOD	k (base e)	NH_3
Sample A	400 mg/L	0.29 d^{-1}	80 mg/L
Sample B	375 mg/L	0.23 d^{-1}	65 mg/L

[10 marks]

2. A 3 m deep sedimentation basin is used to treat an industrial wastewater containing particles whose settling data is presented in **Table Q2**. For a flocculent suspension, assess the removal efficiency for the sedimentation basin with an over-flow rate (V_0) of 3 m/h. If the detention time, t is reduced to 40 minutes, predict any changes in the removal efficiency. Justify your answer.

TABLE Q2: Particle Settling Data

Time, min	Percent suspended solids removed at indicated depth (m)				
	0.5	**1.0**	**1.5**	**2.0**	**2.5**
20	61				
30	71	63	55		
40	81	72	63	61	57
50	90	81	73	67	63
60		90	80	74	68
70			86	80	75
80				86	81

[20 marks]

3. a. An audit was conducted on the management of water use for four operation processes in a refinery. **Table Q3** shows the water use data for the refinery. Propose a network for the target minimum water consumption using the concept of maximum water reuse.

TABLE Q3: 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

[15 marks]

b. Analysis of the data on the management of water use and reuse in the refinery shows that the distributed effluent treatment arrangement is the most cost effective. Assess the reliability of this statement.

[5 marks]

4. A primary classifier is to be designed for an effluent treatment plant in Kuala Lipis, Pahang. It was observed that the average flow rate at the plant is 20,000 m^3/d, whilst the highest observed peak daily flow rate is 50,000 m^3/d. Assume that a minimum of two clarifiers will be used in the plant, with an overflow rate of 40 $m^3/m^2 \cdot d$ at average flow and a side water depth of 4 m.

The following data are available:

Cohesion constant	$k = 0.05$
Specific gravity	$s = 1.25$
Acceleration due to gravity	$g = 9.81\ m/s^2$
Diameter of particles	$d = 100\ \mu m = 10 \times 10^{-6}\ m$
Darcy-Weisbach friction factor	$f = 0.02$
Empirical constants for BOD	a = 0.018, b = 0.020
Empirical constants for TSS	a = 0.0075, b = 0.014

Design the rectangular primary classifiers with a channel width of 6 m for the plant. Estimate the BOD and TSS removal at average and peak flow. Predict if the material will become re-suspended. Justify your answer.

[20 marks]

5. a. You have been assigned to assess an activated-sludge system design for wastewater treatment of a rubber processing industry. **Table Q5** shows the information for the system design. There is no nitrification at the selected SRT and temperature. Assess the biodegradable COD (g/m^3), aeration tank oxygen requirement (kg/d) and the oxygen demand and aeration tank uptake rate (in mg/L·hr).

TABLE Q5: Activated-sludge System Design data

Parameter	Unit	Value
Flow	m^3/d	10 000
Influent BOD	g/m^3	150
Effluent BOD	g/m^3	2
τ	h	4
SRT	d	6
Wastewater Synthesis yield, Y	g VSS/g bCOD	0.40
Cell debris yield, f_d	g VSS/g VSS	0.15
Endogenous decay, k_d	g VSS/g VSS•d	0.08
nbVSS	g/m^3	40
Temperature	°C	10

[14 marks]

b. The pulp and paper industry has traditionally been a concern to the environmentalists due to the intensity of its waste discharges. Outline the characteristics and sources of wastewater from this industry and their effects on the environment. Categorise the relevant laws regarding the discharge requirements for this industry.

[6 marks]

APPENDIX: List of Equations

$$BOD, \frac{mg}{L} = \frac{D_1 - D_2}{P}$$

$$BOD_t = UBOD(1 - e^{-k_1 t})$$

$$r_m = K_L a(C - C)$$

$$r_C = \frac{dC}{dt} = K_L a(C) - K_L a(C_S)$$

$$K_L a_{(T)} = K_L a_{(20^oC)} \theta^{T-20}$$

$$E = \frac{V(K_L a)(C_S - C)}{Q_{air} \rho_{air} (0.23)}$$

$$v_H = \left(\frac{8k(s-1)gd}{f} \right)^{1/2}$$

$$bCOD = 1.6BOD = S$$

$$P_X = \frac{QY(S_O - S)}{1 + (k_d)SRT} + \frac{f_d k_d (QY)(S_O - S)SRT}{1 + (k_d)SRT} + \frac{QY_n(NO_x)}{1 + (k_{dn})SRT} + Q(nbVSS)$$

$$R_O = Q(S_O - S) - 1.42P_X$$

$$OUR = \frac{R_O}{V}$$

$$V = Q\tau$$

$$X = \frac{P_X(SRT)}{V}$$