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	**: CVX6345 Environmental Engineering**
Academic Year	: 2020/2021
Date	: 28th January 2022
Time	: 1400-1700hrs
Duration	: **03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **SEVEN (07)** questions on **FIVE (05)** pages.
3. Answer **FIVE(05)** questions
4. Answer for each question should commence from a new page.
5. Necessary additional information is provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

Question 1

A residential housing scheme produce a primary treated wastewater flow rate of 0.15 m^3/s with 120 mg/L of BOD_5. Due to the space limitation caused by urbanization, the available space for aeration tank is 330 m^3. Review whether the space is adequate for an activated sludge aeration basin. (20 marks)

Assumptions:

- Effluent BOD_5 is 30 mg/L
- Steady state prevails in the system
- BOD_5 of suspended solids is 20 mg/L
- Mixed Liquored Volatile Suspended Solid (*MLVSS*) in the aeration tank 2000 *mg/L*
- Growth constants: K_s= 100 *mg/L* BOD_5; μ_m=2.5 d^{-1}; k_d=0.05 d^{-1};
- Net waste activated sludge production (P_x)= 380 *kg/d* of *VSS*

$$S = \frac{K_s(1+k_d\theta_c)}{\theta_c(\mu_m - k_d)-1} \quad (1)$$

$$X = \frac{\theta_c(Y)(S_0-S)}{t_0(1+k_d\theta_c)} \quad (2)$$

$$P_x = Y_{obs}Q(S_0 - S) \quad (3)$$

$$Y_{obs} = \frac{Y}{1+k_d\theta_c} \quad (4)$$

$$\frac{F}{M} = \frac{QS_0}{VX} \quad (5)$$

Q = Wastewater flow rate into the aeration tank, m^3/d
X = Microorganism concentration in the aeration tank, mg/L
S = Soluble BOD_5 in the aeration tank and effluent, mg/L
S_0 = Soluble BOD_5 in the influent, mg/L
θ_c = Mean cell residence time, d
V = volume of the aeration tank, m^3
K_s = Half velocity constant
μ_m = Maximum growth rate constant, d^{-1}
k_d = Decay rate of microorganisms, d^{-1}
Y = Yield coefficient, mg/mg
Y_{obs} = Observed yield, kg MLVSS/kg BOD_5 removed
P_x = Net waste activated sludge produced each day, kg/d in VSS
t_o = hydraulic retention time

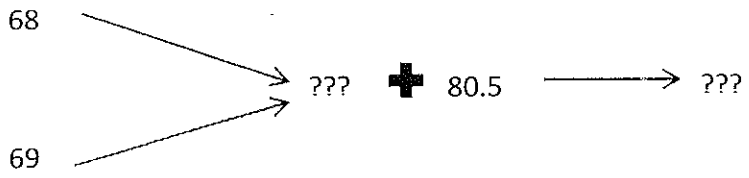
Question 2

2.1) Describe the terms in following equation and explain significance of calculating P_{rms}. (4 marks)

$$P_{rms} = \left|\frac{1}{T}\int_0^T P^2(t)\,dt\right|^{1/2}$$

2.2) Explain the terms sound power (W) and sound intensity (I) (4 marks)

2.3) What is the sound power level results from combining the following three sound levels, 68 dB, 69 dB and 80.5 dB. (6 marks)



2.4) Calculate the average sound pressure level for the three sound levels in above 2.3 (6 marks)

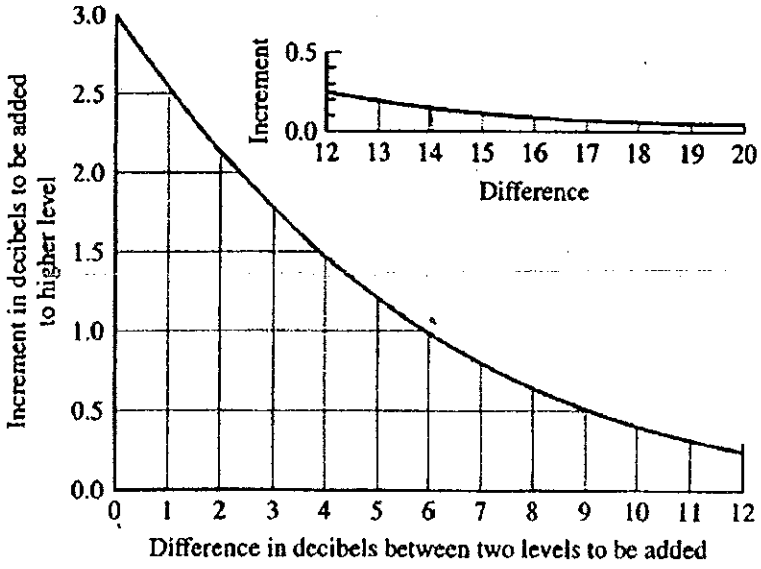


Figure 1

Question 3

3.1) An air sample of 1 m^3 was found to contain 80mg/m^3 of NO_2. When the air sample was taken, the temperature and pressure were 25 °C and 103.193 kPa, respectively. What was the NO_2 concentration in ppm when sample was done? (5 marks)

Data :
Volume of air : 22.414 L/mole of air at 0 °C and 101.325 kPa
Atomic weights: N-14.01 g, O-16 g

3.2) Determine the height of a packed tower which reduces NH_3 in air from a concentration of 0.05 kg/m^3 to a concentration of 0.0005 kg/m^3. (15 marks)

Following data are given with usual notations:
Column diameter=3 m
Operating temperature = 18 °C
Operating pressure = 101.325 kPa
Hg= 0.438 m
H_l= 0.25 m
Qg= Ql= 10 kg/s
m = 1.068
Gram molecular weight of NH_3 17.03g

Incoming liquid is water free of NH_3 and gram molecular weight of air is 28.97g and the density of 1.185 kg/m^3 at 25 °C

$$N_{og} = \frac{\ln\left|\left(\frac{y_1 - mx_2}{y_2 - mx_2}\right)(1 - A) + A\right|}{1 - A}$$

Where;

y_1, y_2 = mole fraction of pollutant in the gas phase at inlet and outlet of tower, respectively
m = slope of equilibrium curve defined by Henry's law = y*/x* in mole fraction units (m has no units)
x_2 = mole fraction of pollutant in the liquid phase entering the tower
A = mQ_g/Q_1
Q_1 = liquid flow rate, kg · mole/h · m^2
Q_g = gas flow rate, kg · mole/h · m^2

$$H_{og} = H_g + AH_l$$

where H_g and H_1 are complex functions of the flow rate, surface area of the packing, **viscosity** of the liquid and air, and the diffusivity of the pollutant gas.

Question 4

4.1) Please explain the following terms; (3 marks)

- Hardness
- Temporary hardness
- Permanent hardness

4.2) Please explain five steps in lime-soda softening with reactions (5 marks)
4.3) Please explain the principles of Ion exchange softening (2 marks)
4.4) Briefly explain the colloidal stability and significance of coagulation (4 marks)
4.5) Explain three properties which should be present in a coagulant (3 marks)
4.6) Briefly explain the alum- lime coagulation in water treatment (3 marks)

Question 5

5.1) Design an equalization basin for the cyclic flow pattern given in Table 1. Provide a 25 percent excess capacity for equipment, unexpected flow variations, and solids accumulation. (12 marks)

Table 1

Time, h	Flow, m^3/s	BOD_5, mg/L	Time, h	Flow, m^3/s	BOD_5, mg/l
0000	0.0481	110	1200	0.0718	160
0200	0.0226	53	1400	0.0750	140
0400	0.0187	32	1600	0.0806	130
0600	0.0226	66	1800	0.0854	125
0800	0.0509	125	2000	0.0781	200
1000	0.0670	150	2200	0.0583	170

5.2) Evaluate the impact of equalization on the mass loading of BOD_5. (8 marks)

Question 6

6.1) Explain the term limnology and describe three strata formed in lakes (4 marks)
6.2) Describe four major biological zones of a lake (4 marks)
6.3) Describe lake productivity and classification of lakes according to productivity (5 marks)
6.4) Describe Eutrophication, cultural eutrophication, macro nutrient requirements and limiting nutrient requirements and the sources of limiting nutrients in lakes (7 marks)

Question 7

7.1) Explain following terms;

- Theoretical Oxygen Demand (2 marks)
- Chemical Oxygen Demand (2 marks)
- Biological Oxygen Demand (2 marks)

7.2) Explain the terms in following two equations; (4 marks)

$$BOD_t = L_o(1 - e^{-kt})$$

7.3) A small town discharges 17,360 m^3/d of treated wastewater into the river Blue. The treated wastewater has a BOD_5 of 12 mg/L and a k of $0.12d^{-1}$ at 20°C. The river Blue has a flow rate of 0.43 m^3/d and an ultimate BOD of 5 mg/L. The DO of the river is 6.5 mg/L and the DO of the wastewater is 1 mg/L. The stream temperature is 10°C and the wastewater temperature is 10°C. It is given that the saturated DO levels at 10 °C is 11.33 mg/L. Compute;

- The Initial DO (2 marks)
- Initial ultimate BOD after mixing (6 marks)
- Initial Deficit in DO (2 marks)