Second Semester Examination
2018/2019 Academic Session

June 2019

EAP215 – Water Supply and Treatment Engineering
(Kejuruteraan Bekalan dan Olahan Air)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions : This paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions.

*[**Arahan** : Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a). A housing scheme consists of 2000 units of double storey house. Each unit has a floor area of 1200 square feet. The building is made up of ordinary construction. Domestic water demand is estimated at 300 litres per capita per day with population equivalent of 6 per unit. Estimate the total flow required. Refer **Table 1**, **Table 2** and the **Appendix** for the estimation.

Satu skim perumahan terdiri daripada 2000 unit rumah dua tingkat. Setiap unit mempunyai keluasan lantai 1200 kaki persegi. Bangunan ini terdiri daripada pembinaan biasa. Permintaan air domestik dianggarkan pada 300 liter per kapita sehari dengan penduduk setara seramai 6 setiap unit. Anggarkan jumlah aliran yang diperlukan. Rujuk ***Jadual 1, Jadual 2*** *dan* ***Lampiran*** *untuk anggaran tersebut.*

Table 1: Residential flow duration
Jadual 1: Tempoh aliran kediaman

Required fire flow (litre/minute)/ *Aliran kebakaran diperlukan (liter /minit)*	Duration (hour)/ *Tempoh (jam)*
<3780 (<1000 gpm)	4
3780 – 4725 (1000 – 1250 gpm)	5
4725 – 5670 (1250 -1500 gpm)	6
5670 – 6615 (1500 – 1750 gpm)	7
6615 – 7560 (1750 – 2000 gpm)	8
7560 – 8505 (2000 – 2250 gpm)	9
>8505 (> 2250 gpm)	10

Table 2: Coefficient related to the type of construction
Jadual 2: Pekali berkaitan dengan jenis pembinaan

Type of construction/ Jenis pembinaan	Coefficient value/ *Nilai Pekali*
Wood Frame	1.5
Ordinary construction	1.0
Non-combustible construction	0.8
Fire Resistive Construction	0.6

[10 marks/*markah*]

(b). Water consumption per capita include normal commercial and industrial use, domestic use and unaccounted for water losses. If there is provision in the development plan for specific industrial areas, additional water demand for such usage should be considered. Explain **FIVE (5)** factors that affect the water consumption.

*Penggunaan air per kapita adalah termasuk kegunaan komersil dan perindustrian yang biasa, penggunaan domestik dan kehilangan air yang tidak dapat dikesan. Sekiranya terdapat peruntukan dalam pelan pembangunan untuk kawasan perindustrian tertentu, permintaan air tambahan bagi penggunaan sedemikian hendaklah dipertimbangkan. Jelaskan **LIMA (5)** faktor yang mempengaruhi penggunaan air.*

[10 marks/*markah*]

2. (a). Explain the following terms for water quality characteristics and provide **TWO (2)** examples for each one.

*Terangkan terminologi bagi ciri-ciri kualiti air berikut dan berikan **DUA (2)** contoh untuk setiap satu.*

(i). Physical
Fizikal

(ii). Chemical
Kimia

(iii). Biological
Biologi

[9 marks/*markah*]

(b) A private water supply company is surveying and analyzing the water samples collected along Sungai Kerian to select a point to abstract water for the residents living in Bandar Baharu. The water quality results are as follows, (i) BOD = 159 mg/L, (ii) COD = 95 mg/L, (iii) TSS = 47 mg/L, (iv) NH_3N = 84 mg/L, (v) pH = 8.6 and (vi) DO = 5.6 mg/L. Calculate the water quality index (WQI) of the river. Conclude the classification of the river and its suitability of usage based on **Table 3**.

*Satu syarikat pembekalan air memerhati dan menganalisa sampel-sampel air yang dikumpulkan disepanjang Sungai Kerian untuk memilih satu punca yang sesuai bagi mengepam air untuk para penduduk yang tinggal di kawasan Bandar Baharu. Berikut adalah nilai-nilai kualiti air yang dikumpulkan, (i) BOD = 159 mg/L, (ii) COD = 95 mg/L, (iii) TSS = 47 mg/L, (iv) NH_3N = 84 mg/L, (v) pH = 8.6 and (vi) DO = 5.6 mg/L. Kirakan indeks kualiti air (WQI) bagi sungai tersebut. Simpulkan klasifikasi sungai tersebut dan kesesuaian penggunaan air sungai berdasarkan **Jadual 3**.*

Table 3: Interim National River Water Quality Standards
Jadual 3: Piawaian Interim Kebangsaan Kualiti Air Sungai

Class / *Parameter*	I	II	III	IV	V
BOD	***<1***	***1-3***	***3-6***	***6-12***	***>12***
COD	***<10***	***10-25***	***25-50***	***50-100***	***>100***
NH3N	***<0.1***	***0.1-0.3***	***0.3-0.9***	***0.9-2.7***	***>2.7***
DO	***>7***	***5-7***	***3-5***	***1-3***	***<1***
pH	***>7***	***6-7***	***5-6***	***<5***	***>5***
SS	***<25***	***25-50***	***50-150***	***150-300***	***>300***
WQI	**>92.7**	**76.5-92.7**	**51.9-76.5**	**31.0-51.9**	**<31.0**

[5 marks/*markah*]

(c) Apart from WQI value, explain **THREE (3)** other factors that should be taken into consideration for river water as a source of drinking water supply.

*Selain daripada nilai WQI, terangkan **TIGA (3)** faktor yang perlu dipertimbangkan untuk air sungai sebagai punca bekalan air minuman.*

[6 marks/*markah*]

3. (a) Three water samples were analyzed for biochemical oxygen demand (BOD). After 5 days of incubation, the final dissolved oxygen measured for bottle 1, bottle 2 and bottle 3 are 6.5, 3.2 and 4.2 mg/L, respectively. The BOD values are found to be 90, 228 and 112 mg/L for each water sample and the sample volumes for each bottle are 5, 5 and 10 mL, respectively. Calculate the values of the initial dissolved oxygen for each water sample.

Tiga sampel air telah dianalisis untuk keperluan oksigen biokimia (BOD). Selepas 5 hari pengeraman, oksigen terlarut akhir yang dikira untuk botol 1, botol 2 dan botol 3 masing-masing adalah 6.5, 3.2 dan 4.2 mg/L. Nilai-nilai BOD adalah 90, 228 dan 112 mg/L bagi setiap sampel air dan isipadu sampel bagi setiap botol adalah 5, 5 dan 10 mL, setiap satu. Kirakan nilai oksigen terlarut awal bagi setiap sampel air.

[10 marks/*markah*]

(b) Discuss the health impact of iron and manganese in drinking water and explain the treatment method to remove these two heavy metals from groundwater.

Bincangkan akibat besi dan mangan di dalam air minuman terhadap kesihatan dan bincangkan secara ringkas bagaimana untuk menyingkirkan kedua-dua logam berat ini daripada air -tanah.

[6 marks/*markah*]

(c) Explain **TWO (2)** differences between coagulation and flocculation in drinking water treatment process.

*Terangkan **DUA (2)** perbezaaan antara penggumpalan dan pengelompokan dalam proses rawatan air minuman.*

[4 marks/*markah*]

4. (a). Explain the importance of jar test with respect to water treatment process which is carried out at the water treatment plant.

Terangkan kepentingan ujian balang dalam proses olahan air yang dijalankan di loji olahan air.

[3 marks/*markah*]

(b). Treatment of 35,000 m^3/day of water requires 20 mg/L of alum as coagulant. The natural alkalinity of the water is equivalent to 4 mg/L as $CaCO_3$. Determine the required quantities of quicklime (containing 80% CaO) and alum in kg/day.

Kadar olahan air sebanyak 35,000 m^3/hari memerlukan dos tawas sebanyak 20 mg/L sebagai penggumpal. Kadar alkaliniti semulajadi air adalah bersamaan dengan 4 mg/L sebagai $CaCO_3$. Tentukan kuantiti kapur tohor (mengandungi 80% CaO) dan tawas dalam kg/hari.

(Note: $[Ca^{2+}]$ = 40.1 g/mol, [C] = 12 g/mol, [O] =16 g/mol)

[5 marks/*markah*]

(c). A water treatment plant is designed to cater a population of 31,000 and per capita consumption is 240 litres per day. Coagulation process involves the construction of one mechanical rapid mixing tank with a velocity gradient, G equals to 700 s^{-1} and a retention time of 1½ minutes. In the flocculation process, two tanks of equal size are constructed in series. Velocity gradients for the first and second tanks are 60 s^{-1} and 40 s^{-1}, respectively. Retention time in each tank is 12 minutes with the dynamic viscosity of water 1.145×10^{-3} Nsm^{-2}. Calculate the following parameters:

Sebuah loji olahan air direkabentuk untuk menampung populasi sebanyak 31,000 dengan penggunaan per kapita sebanyak 240 liter sehari. Proses pengentalan melibatkan pembinaan satu tangki pecampur laju mekanikal dengan kecerunan halaju, G adalah 700 s^{-1} dan masa tahanan selama 1½ minit. Dalam proses penggumpalan, dua tangki sama saiz dibina secara siri. Kecerunan halaju bagi tangki pertama dan kedua adalah masing-masing 60 s^{-1} dan 40 s^{-1}. Masa tahanan untuk setiap tangki adalah 12 minit dengan kelikatan dinamik air $1.145 \times 10^{-3} Nsm^{-2}$. Kirakan semua parameter berikut:

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(i). Volume of the coagulation tank
Isipadu tangki penggumpalan

(ii). Power input in the coagulation tank
Kuasa masukan dalam tangki penggumpalan

(iii). Volume of the flocculation tank
Isipadu tangki pengelompokan

(iv). Power input at each of the flocculation tank
Kuasa masukan setiap tangki pengelompokan

[12 marks/*markah*]

5. (a). Explain **TWO (2)** factors that influence the effectiveness of chlorination process for potable water treatment.

*Jelaskan **DUA (2)** faktor yang akan mempengaruhi keberkesanan proses pengklorinan untuk olahan air minuman.*

[5 marks/*markah*]

(b). An engineer conducted a site visit to a particular treatment plant. A measurement on the sedimentation tank is made in order to estimate the flow rate. The ratio of the depth of water to the width of the tank is 1:1.64, and the ratio of the width to the length of the tank is 1:4. The surface loading, which is in m/day, is 0.30 times the surface area of the tank. The width of the tank is 4.1 m. Determine the dimension of the tank, the length of outlet weir and its flow rate.

Seorang jurutera membuat lawatan ke sebuah loji olahan air. Penyukatan dibuat terhadap tangki enapan untuk menentukan kadar alir. Nisbah kedalaman air kepada lebar tangki ialah 1:1.64, dan nisbah lebar kepada panjang tangki ialah 1:4. Beban permukaan dalam unit m/hari, adalah 0.30 kali luas permukaan tangki. Lebar tangki ialah 4.1 m. Tentukan dimensi tangki, panjang alur limpah dan kadar alir.

[8 marks/*markah*]

(c). A dual medium filter is composed of 0.3 m thick anthracite (mean size of 2.0 mm) that is placed over a 0.6 m thick sand (mean size 0.7 mm) with a filtration rate of 9.78 m/h. Assume the grain sphericity is $\Psi = 0.75$ and porosity for both filter media is 0.4. Calculate the head loss of the filter at 27^{o}C. (Given μ = 27^{o}C is 0.864 X 10^{-6} Ns/m^{2})

Sebuah penapis dual media terdiri daripada 0.3 m tebal antrasit (saiz purata 2.0 mm) yang diletakkan di atas 0.6 m tebal pasir (saiz purata 0.7 mm) dengan kadar tapisan 9.78 m/h. Andaikan kesferaan butiran ialah $\Psi = 0.75$ *dan nilai keliangan untuk kedua-dua media ialah 0.4. Kirakan kehilangan turus penapis pada suhu 27^{o}C. (Diberi μ at 27^{o}C is 0.864 X 10^{-6} Ns/m^{2})*

[7 marks/*markah*]

6. (a). Non-revenue water (NRW) is defined as water produced by treatment plants but does not reach the customer. After the water is distributed, there are losses that occur to this treated water and the losses can either be classified as physical or commercial losses. Describe **THREE (3)** types of commercial losses of treated water.

Air tidak berhasil (NRW) adalah didefinisikan sebagai air yang dihasilkan oleh loji rawatan tetapi tidak mencapai pelanggan. Selepas air diagihkan, terdapat kehilangan yang berlaku kepada air yang dirawat ini dan kehilangan boleh diklasifikasikan sebagai kehilangan fizikal atau komersil. Terangkan ***TIGA (3)*** *jenis kehilangan komersil air terawat*.

[6 marks/*markah*]

(b). **Figure 1** shows a water reticulation system. Estimate the flow rate in each pipeline using Hardy-Cross Method and Hazen-William formula up to two iterations. Adopt Hazen-William coefficient, C as 100. Use initial flow rate of 80 litres per second (L/s) from point A to B. The lengths and diameters for pipes AB, BC, CD, and AD are as follows:

Rajah 1 *menunjukkan sebuah sistem rangkaian air. Anggarkan kadar aliran dalam setiap saluran paip menggunakan Kaedah Hardy-Cross dan formula Hazen-William, sehingga dua lelaran. Gunakan pekali Hazen-William, C, sebagai 100. Gunakan aliran awal sebanyak 80 liter sesaat (L / s) dari titik A hingga B. Panjang dan diameter bagi paip AB, BC, CD, dan AD adalah seperti berikut:*

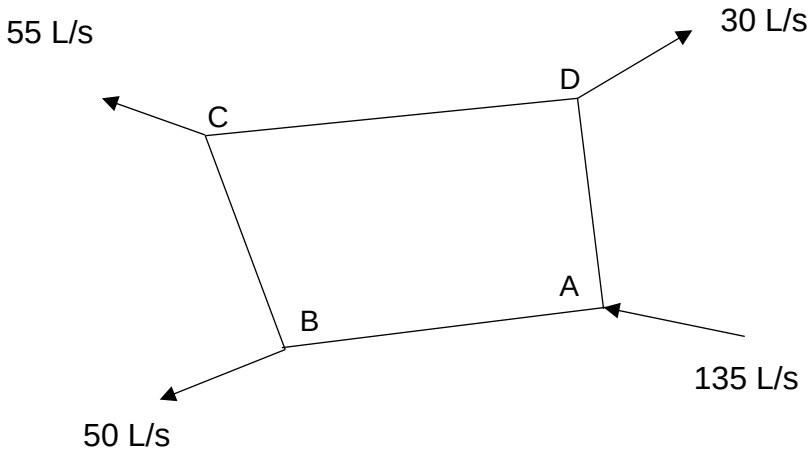

Figure 1: Water Reticulation System
Rajah 1: Sistem Rangkaian Air

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Pipe/*paip* AB: length*/panjang* = 900 m and diameter = 250 mm
Pipe/*paip* BC: length*/panjang* = 650 m and diameter = 200 mm
Pipe/*paip* CD: length*/panjang* = 900 m and diameter = 200 mm
Pipe/*paip* AD: length*/panjang* = 550 m and diameter = 250 mm

[14 marks/*markah*]

APPENDIX/*LAMPIRAN*

Equations related to water supply:/*Persamaan berkaitan bekalan air:*

$$F = 18C(A)^{0.5}$$

$$G = \left(\frac{P}{\mu V}\right)^{1/2}$$

$$P = \frac{1}{2}C_d \rho A v^3$$

$$P = \rho Q g h$$

$$h_L = KQ^2$$

$$\frac{h}{L} = \frac{k\mu(1-\varepsilon)^2}{g\rho\varepsilon^3} - \left(\frac{A}{V}\right)v$$

$$H_L = \frac{12.25 \times 10^9}{D^{4.87}} L \left[\frac{Q}{C}\right]^{1.85}$$

$$F = \frac{V_1}{(g d_1)^{1/2}}$$

$$Re = \frac{\rho V d}{\mu}$$

$$\Delta H = \frac{n v_1^2 + (n-1)v_2^2}{2g}$$

$$v_s = \frac{g d^2(\rho_s - \rho_w)}{18\mu}$$

$$V_s = \frac{Q}{A}$$

$$D = V_s t$$

$$L = \frac{0.2Q}{HV_s}$$

$$\Delta = -\frac{\sum H}{n \sum \frac{H}{Q_a}}$$

$WQI = (0.22*SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16*SISS) + (0.12*SIpH)$

i) Sub-index for DO

$SIDO = 0$	for $x \leq 8$
$SIDO = 100$	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 – 0.00020x^3$	for $8 < x < 92$

ii) Sub-Index for BOD

$SIBOD = 100.4 – 4.23x$	for $x \leq 5$
$SIBOD = 108*\exp(-0.055x) -0.1x$	for $x > 5$

iii) Sub-Index for COD

$SICOD = -1.33x + 99.1$	for $x \leq 20$
$SICOD = 103*\exp(-0.0157x) – 0.04x$	for $x > 20$

iv) Sub-Index for NH_3-N

$SIAN = 100.5 – 105x$	for $x \leq 0.3$
$SIAN = 94* \exp(-0.573x) – 5* \lvert x-2 \rvert$	for $0.3 < x < 4$
$SIAN = 0$	for $x \geq 4$

v) Sub-Index for TSS

$SISS = 975*\exp(-0.00676x) + 0.05x$	for $x \leq 100$
$SISS = 71*\exp(-0.0016x) – 0.015x$	for $100 < x <1000$
$SISS = 0$	for $x \geq 1000$

vi) Sub-Index for pH

$SIpH = 17.2 – 17.2x + 5.02x^2$	for $x < 5.5$
$SIpH = -242 + 95.5x – 6.67x^2$	for $5.5 \leq x < 7$
$SIpH = -181 + 82.4x – 6.05x^2$	for $7 \leq x < 8.75$
$SIpH = 536-77.0x + 2.76x^2$	for $x \geq 8.75$

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