UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2009/2010

SUBJECT NAME	:	WATER SUPPLY DESIGN
SUBJECT CODE	:	BFA 4023
COURSE	:	4 BFF
EXAMINATION DATE	:	APRIL 2010
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **QUESTION 1** and ANY **THREE (3)** OTHER QUESTIONS.

THIS PAPER CONSIST OF ELEVEN (11) PAGES

Q1 A communal domestic water supply is proposed. Design population is 16500 people. Water demand characteristics are tabulated in Table **Q1** below.

Table Q1: Data on average daily demand.

User type	Average daily demand, L/d per person
Domestic	320
Commercial	10
Industrial	10
Public	10
Loss	10

(a) Design a rectangular pre-sedimentation basin, given the following:

Detention time (t) = 3h
Depth (D) = 1.5m
Overflow rate (OFR) = 200 m^3/d per metre length of overflow weir.

Determine the length (L), width (W), and overflow length of the basin.
Assume:

(i) Design flow = Maximum daily demand = 2 x Average daily demand
(ii) L = 10W.

(10 marks)

(b) Design a rectangular cascade aerator that requires 0.2m^2 of surface area per litre/second of flow.

Determine the length (L), and breadth (W) of each cascade.
Assume:

(i) Design flow = Maximum daily flow = 2 x Average daily flow
(ii) There are six (6) cascades, each 1m deep
(iii) L = 6W.

(5 marks)

(c) Design a rectangular flocculation tank (length, L and width, W), given the following:

Design flow = Maximum daily flow = 2 x Average daily flow
Product $G.t = 3.5 \times 10^4$
Velocity gradient, $G = 25$ per second
Tank depth (D) = 1.5m
L = 6W.

Calculate the electrical power required to flocculate the tank contents, using:

$$P = G^2 . V . \mu$$

Where: P = Power in kilowatts (kW)
G = Velocity gradient, per second
V = Volume of the tank, m^3
μ = Dynamic viscosity of water, 0.798×10^{-3} (N-s)/m^2

(10 marks)

Q2 A water supply scheme is proposed. Demand characteristics at full plant capacity are as follows:

Population – 10,000 people
Domestic demand (average) = 0.32m^3 per day per person
Industrial demand = 30% of the average domestic demand
Agriculture demand = 50% of the average domestic demand
Fire fighting flow = 2725 m^3/d
Duration to put off the fire = 2h

Other information:

Maximum Daily Demand = 2 x Average Daily Demand
Peak Hourly Demand = 3 x Average Daily Demand
Plant operation = 24h/d

You are to provide a preliminary design of the following components for the proposed treatment works:

(i) Power capacity of a low lift pump based on maximum daily flow (assume effective lift = 15m).
(ii) Capacity of a high lift pump based on peak hourly flow (assume effective lift = 50m).
(iii) Volume of balancing (equalizing) tank, assuming this volume = 25% of maximum daily flow (based on 24h/d plant operation).

The formula for calculating pump power is given by:

P (in kW) = (0.1135) (Design flow, MLD) (Effective lift, meter)

(25 marks)

Q3 Two processes applied at a water supply works are described as follows.

- Alum coagulation for removing turbidity. Sludge formed is $Al(OH)_3$. (Atomic weights: Al=27; O=16; H=1)

- Carbonate softening for removing magnesium (Mg^{2+}) hardness. Sludge formed is $MgCO_3$. (Atomic weights: Mg =24; C=12; O=16).

With respect to the two different types of sludge and for a given design flow for the water works, explain the following:

(i) Requirement of surface loading rate (SLR). SLR has the units of velocity (m/d) or m^3/d of flow per square metre (m^2) of tank surface area.
(ii) Sludge produced and hence tank volume requirement for sludge handling, and retention time in the tank.

(25 marks)

Q4 (a) Explain the differences between sterilization and disinfection as used in water treatment.

(2 marks)

(b) Explain why you need to have residual chlorine in treated water.

(2 marks)

(c) Sketch a graph of residual chlorine versus chlorine dose.

(2 marks)

(d) What is breakpoint chlorination?

(2 marks)

(e) What is disinfection-by-product (DBP)?

(2 marks)

(f) Explain why the use of chlorine gas is not encouraged at a treatment plant.

(2 marks)

(g) Ozone is used for disinfection of bacteria in water. If a kill of 99.9% is required with ozone residual of 0.5 mg/l, determine the contact time (in seconds) needed.

Use the following equation to calculate t.

$$t = (1/k)\ log_{10}(N_o/N_t)$$

Where: t = contact time (seconds)
N_o = Initial number of bacteria (number or percent)
N_t = Number of organisms remaining (not killed) after time t
k = Disinfection constant for ozone = 2.5×10^{-2} per second.

(13 marks)

Q5 (a) You are required to design several slow sand filters (SSF) based on a total design flow of 3.5 MLD, given the following:

Number of filters, $N = 2.7\ (\text{Total design flow, MGD})^{1/2}$
Hydraulic application rate = 10 m^3/day per surface area, m^2
Depth of filter, D = 1m
1 Gallon = 3.785 L
Design flow = Peak hourly flow = 3 x Average daily flow
Filter is square in shape.

Determine:

(i) Number of filters
(ii) Design flow for every filter
(iii) Surface area of every filter
(iv) Length (L) and Width (W) of every filter.

(15 marks)

(b) List the differences between Slow Sand Filter (SSF) and Rapid Sand Filter (RSF).

(10 marks)

S1 Bekalan air dicadangkan untuk penduduk seramai 16500 orang. Ciri-ciri keperluan air adalah seperti Jadual **S1** berikut.

Jadual S1: Purata kegunaan air harian

Pengguna	Purata kegunaan air harian, liter sehari seorang
Domestik	320
Perniagaan	10
Kilang	10
Awam	10
Kehilangan	10

Dengan menggunakan maklumat dalam Jadual **S1**, anda dikendaki merekabentuk komponen loji air seperti berikut:

(a) Sebuah tangki pra-enapan segi-empat bujur menggunakan maklumat berikut:

Masa tahanan (t) = 3jam
Ukurdalam (D) tangki = 1.5m
Kadar limpahan = 200 m^3/d per meter panjang limpahan

Tentukan panjang (L), lebar (W), dan panjang limpahan tangki.
Anggap:

(i) Kadaralir rekabentuk = Kadaralir harian maksima = 2 x Kadaralir harian purata
(ii) (ii) L = 10W.

(10 markah)

(b) Satu tangki pengudaraan air terjun berasaskan keperluan 0.2m^2 luas permukaan per liter/saat kadaralir rekabentuk.

Kadaralir rekabentuk ialah kadaralir harian maksima, iaitu, 2 kali ganda kadaralir harian purata. Kesemuanya ada enam (6) tangki kecil air terjun pada ukurdalam yang sama, iaitu D = 1m.

Tentukan panjang (L) dan lebar (W) setiap tangki kecil air terjun.

(5 markah)

(c) Rekabentuk satu tangki flokulasi segi-empat bujur, jika diberi maklumat berikut:

Kadaralir rekabentuk = Kadaralir harian maksima = 2 x Kadaralir harian purata
$G.t = 3.5 \times 10^4$
Cerun halaju, $G = 25$ per saat
Ukurdalam tangki (D) = 1.5m
Panjang tangki (L) = 6 x Lebar (W).

Tentukan saiz tangki (L dan W) dan juga kuasa letrik yang diperlukan untuk membaur tangki, menggunakan formula berikut.

$$P = G^2 . V . \mu$$

Di mana: P = Kuasa, Watts (W)
G = Cerun halaju, per saat
V = Isipadu tangki, m^3
μ = Kelikatan dinamik air, 0.798×10^{-3} (N-saat)/m^2

(10 markah)

S2 Satu projek bekalan air dirancang. Berikut adalah maklumat berkaitan rekabentuk projek:

Bilangan penduduk = 10,000 orang
Keperluan domestk (purata) = 0.32m^3 sehari seorang
Keperluan industri (purata) = 30% daripada keperluan domestik
Keperluan pertanian (purata) = 50% daripada keperluan domestik
Kadaralir pemadaman api = 2725 m^3/hari
Masa memadam api = 2 jam
Keperluan harian maksima = 2 x Keperluan harian purata
Keperluan jaman kemuncak = 3 x Keperluan harian purata
Air terawat dipam terus kepada pengguna 24jam sehari.

Anda dikehendaki merekabentuk komponen rawatan air berikut:

(i) Pam kuasa rendah berdasarkan kadaralir harian maksima. Anggap effective lift pam bersamaan 15m.
(ii) Pam kuasa tinggi berdasarkan kadaralir jaman kemuncak (Anggap *effective lift* pam bersamaan 50m).
(iii) Isipadu tangki imbangan
(iv) Isipadu tangki air bersih (Anggap isipadu tangki 25% daripada keperluan harian maksima).

Kuasa pam boleh dikira menggunakan formula berikut:

P (kW) = (0.1135) (Kadaralir rekabentuk, MLD) (Effective lift, meter)

(25 markah)

S3 Berikut ialah dua proses yang digunakan di sebuah loji rawatan air.

- Pengentalan berasaskan alum untuk penyingkiran kekeruhan. Enapcemar terjana ialah $Al(OH)_3$.
- Pelembutan berasaskan karbonat (CO_3) untuk penyingkiran kekerasan magnesium (Mg^{2+}). Enapcemar terjana ialah $MgCO_3$.

Berpandukan dua jenis enapcemar di atas dan untuk satu kadaralir rekabentuk loji tersebut, terangkan perkara-perkara berikut:

(i) Keperluan surface loading rates (SLR). (Unit SLR ialah unit halaju (m/hari) atau kadaralir (m^3/hari) per keluasan permukaan tangki, m^2).

(ii) Enapcemar, dan seterusnya isipadu tangki untuk enapcemar dan juga masa tahanan dalam tangki.

(Berat atom: Al=27; O=16; H=1; Mg=24; C=12)

(25 markah)

S4 (a) Terangkan perbedaan antara sterilization dan disinfection dalam merawat air.
(2 markah)

(b) Terangkan mengapa klorin lebihan perlu dihadirkan dalam air terawat.
(2 markah)

(c) Lakarkan graf klorin lebihan melawan dos klorin.

(2 markah)

(d) Terangkan *breakpoint chlorination.*
(2 markah)

(e) Terangkan disinfection-by-products (DBPs)?
(2 markah)

(f) Terangkan mengapa penggunaan gas klorin tidak digalakkan di loji.
(2 markah)

(g) Ozon digunakan untuk pembasmian bakteria dalam air. Jika peratus pembasmian bakteria (pembunuhan) ialah 99.9% dengan ozon lebihan sebanyak 0.5 mg/l, tentukan masa tindakan antara klorin dan bakteria (t dalam saat).

Berikut ialah formula untuk kiraan t:

$$t = (1/k)\ log_{10}(N_o/N_t)$$

di mana: t = Masa tindakan antara klorin dan bacteria (saat)
N_o = Populasi bakteria peringkat permulaan (bilangan atau peratus)
N_t = Populasi bakteria yang masih hidup selepas masa t
k = Pekali pembasmian untuk ozon, 2.5×10^{-2} per saat.

(13 markah)

S5 (a) Anda dikehendaki merekabentuk beberapa penapis kadar perlahan (SSF) berdasarkan jumlah kadaralir rekabentuk 3.5 MLD, jika diberi parameter-parameter berikut:

Bilangan penapis, $N = 2.7$ (Jumlah kadaralir rekabentuk, MGD)$^{1/2}$
Kadar aplikasi haidrolik = 10 m^3/hari kadaralir rekabentuk per m^2 keluasan penapis
Ukurdalam penapis, D = 1m
1 Gallon = 3.785 liter
Kadaralir rekabentuk = Kadaralir jaman kemeucak = 3 x Kadaralir Harian Purata
Penapis berbentuk segi empat sama.

Tentukan:

(i) Bilangan penapis
(ii) Kadaralir rekabentuk setiap penapis
(iii) Keluasan setiap penapis
(iv) Panjang (L) dan Lebar (W) setiap penapis.

(15 markah)

(b) Senaraikan perbezaan antara Penapis Kadar Perlahan dan Penapis Kadar Deras

(10 markah)