

**CONFIDENTIAL**



**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
SEMESTER I  
SESSION 2011/2012**

**COURSE NAME** : DESIGN OF WATER SUPPLY  
**COURSE CODE** : BFA 4023  
**PROGRAMME** : 4 BFF  
**EXAMINATION DATE** : JANUARY 2012  
**DURATION** : 3 HOURS  
**INSTRUCTION** : ANSWER **FOUR (4)** QUESTIONS

**THIS PAPER CONSISTS OF THIRTEEN (13) PRINTED PAGES**

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**Q1 (a)** List the pollutants that the following processes are normally designed to remove in surface water treatment:

- (i) Conventional treatment for water processing
- (ii) Special treatment
- (iii) Softening

(6 marks)

**(b)** Explain briefly the function of each of the following processes for surface water treatment:

Pre-chlorination

Aeration

Mixing with addition of:

- Lime
- Alum
- Cationic polyelectrolyte

Flocculation

Sedimentation

Filtration

Post chlorination

Fluoridation

Neutralization

Activated carbon

(19 marks)

- Q2** (a) A domestic waterworks is considered for a community of 10,000 people. Average per capita demand is  $0.32\text{m}^3/\text{day}$  and raw water is pumped from a river source using low-lift pumping to a reservoir. Determine the power of the pump set (in kW) required, assuming 20m static head; 3m frictional losses in the transmission pipe; and 7m depth of water in the reservoir. Assume design flow is 1.5 times the average daily demand.

(10 marks)

- (b) Describe the operation of a pumped storage water supply system from low-lift pumping to treatment works to water distribution pipe network with storage facilities. Consider 8h and 24h direct pumping of treated water for estimation of storage to equalize supply and demand. Assume the distribution network covers two service areas in different topography (high ground and low ground). Support your answer with sketches.

(15 marks)

- Q3** A water supply scheme is considered for a community of 10,000 people. Average water demand at full plant capacity is given as follows:

Domestic demand = 320 LPCD

Industrial and development demand = 100% of domestic demand

Water for emergency use = 15% of domestic demand

Fire fighting flow =  $7500\text{m}^3/\text{d}$  for 6h duration

Design criteria are given as follows:

Maximum day demand =  $1.5 \times$  Average daily demand

Peak hourly demand =  $2.0 \times$  Average daily demand

Provide a preliminary design for the following components of the proposed waterworks:

Low lift pumping. Assume effective lift is 20m

High lift pumping. Assume effective lift is 60m

Storage volume for the scheme to operate on 8h pumping

Storage volume for the scheme to operate on 24h pumping

(25 marks)

**Q4 (a)** In what situation do you require a pre-sedimentation basin? (2 marks)

**(b)** A rectangular pre-sedimentation tank is required that will satisfy the following criteria:

Design flow =  $0.14 \text{ m}^3/\text{s}$

Detention time = 4 h

Depth,  $D = 3 \text{ m}$

Weir loading =  $250 \text{ m}^3/\text{d}/\text{m}$

Overflow rate =  $20 \text{ m}^3/\text{d}/\text{m}^2$

**(i)** Determine the volume ( $V$ ), width ( $W$ ), length ( $L$ ) of the tank and flow-through velocity,  $V_{ft}$ . (6 marks)

**(ii)** Comment of the value of  $V_{ft}$  obtained, knowing the function of the basin is to settle the high content of SS in the raw water.

(2 marks)

**(c)** Design of a mechanical flocculation tank is required for a design flow of  $0.1 \text{ m}^3/\text{s}$ , subject to tank depth ( $D$ ) equal to  $4 \text{ m}$  and flow-through velocity  $9 \text{ m}/\text{h}$ .

**(i)** Determine the volume ( $V$ ), length ( $L$ ), and width ( $W$ ) of the tank.

**(ii)** Determine the length and width of each blade if a total of three (3) blades are required across the tank cross-section. Assume the blades take up 10% of the cross sectional area,  $D \times W$ .

**(iii)** Determine the detention time and comment on the result obtained.

(7 marks)

**(d)** Determine the power required for the tank above. Assume the following:

$G = 28$

$Gt = 35000$  ( $t$  is detention time)

Design flow =  $0.1 \text{ m}^3/\text{s}$ .

Dynamic viscosity of water,  $\mu = 0.0008 \text{ N}\cdot\text{s}/\text{m}$ .

(8 marks)

**Q5** (a) Explain the need for alkalinity to be present in raw water before chemical coagulation. (2 marks)

(b) Explain how colloidal matter is removed during flocculation. Use alum ( $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ ) as an example to explain the chemical reaction with  $\text{HCO}_3^-$  (as alkalinity).

Atomic weight: Al=27; S=32; O=16; H=1; and  $\text{CaCO}_3$  has an EW (equivalent weight) of 50 mg/meq.

(7 marks)

(c) (i) Sketch a horizontal flow sedimentation tank

(3 marks)

(ii) Sketch a radial flow sedimentation tank

(3marks)

(iii) A long narrow rectangular sedimentation tank has been sized as follows:

Length (L) = 15m

Width (W) = 4m

Depth (D) = 3m

Weir length ( $L_w$ ) = 20m

Check on the adequacy of the design, given the following conditions:

Detention time = 2h

Surface overflow rate (SOR) =  $20\text{m}^3/\text{d}/\text{m}^2$

Flow-through (horizontal) velocity = 9m/hr

Weir loading =  $250\text{m}^3/\text{d}/\text{m}$

Design flow =  $0.05\text{m}^3/\text{s}$

(10 marks)

- Q6**
- (a) Explain filtration (2 marks)
- (b) Name the key removal mechanisms during filtration following sedimentation. (2 marks)
- (c) Determine the bed area ( $m^2$ ) for a slow sand filter receiving a hydraulic application rate of  $10m^3/d/m^2$ . Design flow is  $0.05m^3/s$ . How many filter units are required if filter bed is limited to  $100m^2$  each? (5 marks)
- (d) Estimate the number of slow sand filters required for a plant with  $4200 m^3/d$  average flow. Hence determine the bed area ( $m^2$ ) for each filter if:
- (i) Hydraulic application rate =  $20 m^3/d/m^2$
  - (ii) Design flow = 2 x Average flow
  - (iii) Number of filters =  $2.7 [\text{Design flow in MGD(US)}]^{1/2}$
  - (iv) Unit filter bed area =  $10m \times 10m$
  - (v)  $1.0 \text{ US gal} = 3.785 \text{ L}$
- (8 marks)
- (e) Tabulate to show comparison between the following types of filter with respect to media depth, specific gravity and size typically used in water treatment:
- (i) Mono-media (all-sand)
  - (ii) Dual-media - using anthracite (top) and sand (bottom).
- (8 marks)

- Q7**
- (i) Sketch a breakpoint chlorination curve and name all the important features.  
(3 marks)
  - (ii) Explain free available chlorine (FAC)?  
(3 marks)
  - (i) Explain combined available chlorine (CAC)?  
(3 marks)
  - (ii) Explain the pH dependency upon the products of the reaction of chlorine with water.  
(3 marks)
  - (iii) Write down the chemical reactions to show the reaction of ammonia ( $\text{NH}_3$ ) with hypochlorous acid (HOCL).  
(3 marks)
  - (iv) Explain the statement, “disinfecting power of free chlorine residual decreases with increasing pH.”  
(5 marks)
  - (v) CAC is less powerful as disinfection than FAC. However, CAC is often established in the treated water entering the distribution system. Why is this so?  
(5 marks)

**S1 (a)** Senaraikan pencemar-pencemar yang selalunya direkabentukkan supaya tersingkir dalam rawatan air permukaan melalui proses berikut:

- (i) Rawatan konvensional bagi pemprosesan air
- (ii) Rawatan khas
- (iii) Pelembutan

(6 markah)

(b) Terangkan secara ringkas fungsi bagi setiap proses dibawah dalam rawatan air permukaan.

Pra pengklorinan

pengudaraan

Pencampuran dengan tambahan:

- kapur
- Alum
- Cationic polyelectrolyte

Pengumpalan

Pengenapan

Penapisan

Pasca Pengklorinan

Pemfluoridaan

Peneutralan

Karbon teraktif

(19 markah)



- Q2** (a) Sebuah kerjaair domestik dipertimbangkan untuk komuniti seramai 10,000 orang. Purata Keperluan per kapita adalah  $0.32\text{m}^3/\text{hari}$  dan sumber air mentah dipam daripada sebuah sungai menggunakan pengepaman angkat rendah ke sebuah takungan. Tentukan kuasa pam ( dalam kW) yang diperlukan dengan mengangap 20m turus statik; 3m kehilangan geseran dalam paip pengagihan; dan air dalam takungan berkedalaman 7m depth. Juga anggap aliran rekabentuk adalah 1.5 kali keperluan purata harian

(10 markah)

- (b) Terangkan operasi sebuah bekalan air dari takungan air terpam mulai dari pengepaman angkat rendah meliputi rawatan selanjutnya ke jaringan paip pengagihan dengan kemudahan penyimpanan. Pertimbangkan operasi pam 8 jam dan 24 jam bagi air terawatt untuk menggarkan jumlah penyimpanan dan keperluan. Anggap jaringan pengagihan meliputi dua kawasan perkhidmatan dalam topografi berbeza ( tanah tinggi dan tanah rendah). Sokong jawapn anda dengan lakaran.

(15 markah)

- Q3** Sebuah skema bekalan air dipertimbangkan untuk sebuah komuniti berjumlah 10,000 orang. Purata keperluan air ketika loji berkapasiti penuh adalah seperti berikut:

Keperluan domestik	=	320 Liter serorang sehari
Keperluan industri dan pembangunan	=	100% keperluan domestik
Air untuk tujuan kecemasan	=	15% keperluan domestik
Aliran pencegahan kebakaran	=	$7500\text{m}^3/\text{hari}$ untuk tempoh 6 jam

Kriteria rekabentuk diberi seperti berikut:

Keperluan Maksimum Harian	=	1.5 x Keperluan Harian Purata
Keperluan Puncak (Jam)	=	2.0 x Keperluan Harian Purata

Sediakan rekabentuk awalan untuk cadangan kerjaair bagi komponen berikut::

- Pengepaman angkat rendah. Anggap angkat effective ialah 20m.
- Pengepaman angkat tinggi. Anggap angkat effective ialah 60m.
- Isipadu simpanan utk skema beroperasi pada pengepaman 8 jam.
- Isipadu simpanan utk skema beroperasi pada pengepaman 24 jam.

(25 markah)

- Q4** (a) Dalam situasi apakah takungan pra pengenapan diperlukan ? (2 markah)
- (b) Sebuah takungan segi empat pra pengenapan diperlukan dengan ciri berikut:  
 Aliran rekabnetuk =  $0.14\text{m}^3/\text{s}$   
 Masa tahanan = 4 jam  
 Kedalaman,  $D = 3\text{ m}$   
 Beban alurlimpah =  $250\text{ m}^3/\text{hari}/\text{m}$   
 Kadar limpahan =  $20\text{ m}^3/\text{hari}/\text{m}^2$
- (i) tentukan isipadu (V), lebar (W), panjang (L) bagi tangki and halaju aliran melalui,  $V_{f-t}$ . (6 markah)
- (ii) berikan komen terhadap nilai  $V_{f-t}$  yang diperolehi, diketahui fungsi takungan adalah untuk mengenal pepejal terampai yang tinggi dari sumber air. (2 markah)
- (c) Rekabentukkan sebuah tangki pengumpulan mekanikal untuk aliran rekabentuk  $0.1\text{ m}^3/\text{s}$ , kedalaman (D) sama dengan 4m dan halaju aliran melalui adalah 9m/jam.
- (i) Tentukan isipadu (V), panjang (L), dan kedalaman (W) tangki..
- (ii) Tentukan panjang dan lebar setiap bilah jika sejumlah tiga bilah diperlukan merangkupi keratan rentas tangki. Anggap setiap bilah menggunakan 10% dari luas keratin rentas,  $D \times W$ .
- (iii) Tentukan masa tahan dan berikan komen bagi jawapan yang diperolehi. (7 markah)
- (d) Tentukan kuasa yang diperlukan untuk tangki diatas. Anggap yang berikut:
- $G = 28$   
 $Gt = 35000$  (t adalah masa tahanan)  
 Aliran rekabentuk =  $0.1\text{m}^3/\text{s}$ .  
 Kelikatan dinamik air,  $\mu = 0.0008\text{ N-s}/\text{m}$ . (8 markah)

**Q5** (a) Terangkan keperluan adanya kealkalian dalam air mentah sebelum koagulasi kimia. (2 markah)

(b) Terangkan bagaimana kolloid disingkirkan semasa pengumpulan. Guna alum ( $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ ) sebagai contoh untuk menerangkan tindakbalas kimia dengan  $\text{HCO}_3^-$  (sebagai kealkalian).

Berat atom: Al=27; S=32; O=16; H=1; dan  $\text{CaCO}_3$  mempunyai EW (berat setara) 50 mg/meq.

(7 markah)

(c) (i) Lakarkan tangki pegenapan aliran datar. (3 markah)

(ii) lakarkan tangki pegenapan jejarian. (3markah)

(iii) Sebuah tangki pegenapan panjang dan sempit mempunyai saiz seperti berikut :

Panjang (L) = 15m  
 Lebar (W) = 4m  
 Kedalaman (D) = 3m  
 Panjang Alurlimpah ( $L_w$ ) = 20m

Semak kecukupan rekabentuk diatas dengan keadaan berikut:

Masa Tahanan = 2jam  
 Kadar limpahan permukaan (SOR) =  $20\text{m}^3/\text{hari}/\text{m}^2$   
 Halaju aliran melalui ( datar) = 9m/jam  
 Beban alurlimpah =  $250\text{m}^3/\text{hari}/\text{m}$   
 Aliran rekabentuk =  $0.05\text{m}^3/\text{s}$

(10 markah)

- Q6**
- (a) Terangan penapisan (2 markah)
- (b) Namakan mekanisma penyingkiran utama semasa penapisan diikuti penganapan. (2 markah)
- (c) Tentukan luas dasar ( $m^2$ ) untuk penapis pasir perlahan yang dikenakan air pada kadar hidraulik  $10m^3/hari/m^2$ . Aliran rekabentuk adalah  $0.05m^3/s$ . Berapa banyak penyaring diperlukan jika dasar penyingkir dihadkan kepada  $100m^2$  setiap satu? (5 markah)
- (d) Anggarkan jumlah penapis pasir perlahan yang diperlukan untuk sebuah loji dengan aliran purata  $4200 m^3/hari$ . Dari itu, tentukan luas dasar penapis ( $m^2$ ) untuk setiap penapis jika:
- (i) Kadar hidraulik =  $20 m^3/hari/m^2$
  - (ii) Aliran rekabentuk =  $2 \times$  Purata aliran
  - (iii) Jumlah penapis =  $2.7 [\text{Aliran rekabentuk dalam MGD(US)}]^{1/2}$
  - (iv) Luas dasar penapis =  $10m \times 10m$
  - (v)  $1.0 \text{ US gal} = 3.785 \text{ L}$
- (8 markah)
- (e) Tunjukkan perbezaan bagi penapis berikut terhadap ciri kedalaman media, graviti tentu, dan tipikal saiz yang digunakan dalam rawatan air:
- (i) Mono-media (semua pasir)
  - (ii) Dual-media - guna anthracite (atas) dan pasir (bawah).
- (8markah)

- Q7**
- (i) Lakarkan lengkung titik putus pengklorinan dan namakan semuaciri yang penting.  
(3 markah)
  - (ii) Terangkan klorin bebas tersedia ?  
(3 markah)
  - (iii) Terangkan klorin berpadu tersedia ?  
(3 markah)
  - (iv) Terangkan ketergantungan pH terhadap hasil daripada tindakbalas klorin dengan air.  
(3markah)
  - (v) Tuliskan tindakbalas kimia menunjukkan tindakbalas ammonia ( $\text{NH}_3$ ) dengan hypochlorous acid (HOCL).  
(3markah)
  - (vi) Terangkan kenyataan berikut” kuasa pembasmian klorin bebas baki menurun dengan kenaikan pH”  
(5 markah)
  - (vii) Klorin berpadu tersedia adalah kuasa berkuasa sebagai penyahpenyakit berbanding klorin bebas tersedia. Bagaimanapun klorin berpadu tersedia selalunya ada dalam air terawat memasuki sistem pengagihan. Mengapa begini ?  
(5 markah)