UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2009/2010 Academic Session

April/May 2010

IEK 211 – EQUIPMENT DESIGN FOR WATER TREATMENT
[REKABENTUK PERALATAN PENGOLAHAN AIR]

Duration: 3 hours
Masa: [3 jam]

Please check that this examination paper consists of SEVEN pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer FIVE (5) questions. You may answer the questions either in Bahasa Malaysia or in English.

[Arahan: *Jawab LIMA (5) soalan. Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

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

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

…2/-

1. Calculate the necessary amounts of lime and soda ash to soften a water which contains a total hardness of 215 mg/L as $CaCO_3$, alkalinity of 185 mg/L as $CaCO_3$, Mg^{2+} 15.8 mg/L as Mg^{2+}, Na^{+} 8 mg/L as Na^{+}, SO_4^{2-} 28.6 mg/L as SO_4^{2-}, Cl^{-} 10.0 mg/L as Cl^{-}, NO_3^{-} 1.0 mg/L as N, CO_2 25.8 mg/L as CO_2, and has a pH of 7.07.

   (100 marks)

2. A rapid-mix unit is to be designed for 50,000-m^3 /day raw water. Using a detention time of 30s, determine the size of the tank V and the motor horsepower of the mixer R_i, assuming a shaft h and a motor efficiency M of 75% and 90%, respectively. Assume a water temperature of 20°C.

   Given:

$$G = \sqrt{\frac{P_f}{\mu \forall}}$$

   $\mu = 10(10^{-4})$ kg/ms
   $R_i = R_f$ / h M
   $G = 800\ s^{-1}$
   One hp = 745.7 Watts

   (100 marks)

3. The prototype detention time and overflow rate of a settling basin were calculated to be 44 min and 0.10m/min respectively. Design a rectangular settling basin using these values for a flow rate of 20 000 m^3/d.

   Given:

$$Z_0 = \upsilon_0 t_0 \qquad \frac{Z_0}{\upsilon_0} = \frac{WZ_0L}{Q}$$

   u_h = horizontal velocity = 0.8m/h

   (100 marks)

4. A raw water to be treated by the lime-soda process to the minimum hardness possible has the following characteristics: CO_2=22.0mg/l, Ca^{2+}=80mg/L, Mg^{2+}=12.0mg/L, Na^{+}= 46.0mg/l, HCO_3^{-} = 152.5 mg/L and SO_4^{2-}=216.0mg/L.

   (a) Check if the numbers of equivalents of positive and negative ions are balanced.

   (50 marks)

   (b) For a flow of 25, 000 m^3/day, calculate the chemical requirements and the mass solids and the volume of sludge produced.

   Assume that the lime used is 90% pure and the soda ash used is 85% pure. Also, assume that the specific gravity of the sludge is 1.04.

   C = 12, O = 16, Ca = 40, M g= 24, Na = 23, H = 1.0, S = 32.

   For CO_2: $CO2 + CaO + H2O \rightarrow CaCO_3 + H_2O$

   For $Mg(HCO_3)_2$: $Mg(HCO_3)_2 + 2CaO + 2H_2O \rightarrow Mg(OH)_2 + 2CaCO_3 + 2H_2O$

   For $Ca(HCO_3)_2$: $Ca(HCO_3)_2 + CaO + H2O \rightarrow 2CaCO_3 + H_2O$

   For $CaSO_4$: $CaSO_4 + Na_2CO_3 \rightarrow CaCO3 + Na_2SO_4$

   (50 marks)

5. A water treatment plant is being designed to process 50,000 m^3/d of water. Jar testing and pilot plant analysis indicate that an alum dosage of 40 mg/L with flocculation at a *Gt* value of 4.0 x 10^4 produces optimal results at the expected water temperatures of 15°C.

   Determine:

   (a) The monthly alum requirement.

   (b) The flocculation basin dimensions if three cross-flow horizontal paddles are to be used. The flocculator should be a maximum of 12 m wide and 5 m deep in order to connect appropriately with the settling basin.

(c) The power requirement.

$$D = C_D A_P \rho \frac{\upsilon_P^2}{2}$$

C_D = dimensionless coefficient of drag, 1.8 for flat blades

A_P = area of paddle blades, m^2

ρ = density of water, kg/m^3

$$P = \frac{C_D A_P \rho \upsilon_P^3}{2}$$

$$G = \left(\frac{C_D A_P \rho \upsilon_P^3}{2V\mu} \right)^{1/2}$$

(100 marks)

1. *Kira jumlah kapur dan serbuk soda yang diperlukan untuk melembutkan air yang mengandungi jumlah kekerasan 215 mg/L $CaCO_3$, kealkalian 185 mg/L $CaCO_3$, Mg^{2+} 15.8 mg/L sebagai Mg^{2+}, Na^{+} 8 mg/L sebagai Na^{+}, SO_4^{2-} 28.6 mg/L sebagai SO_4^{2-}, Cl^{-} 10.0 mg/L sebagai Cl^{-}, NO_3^{-} 1.0 mg/L sebagai N, CO_2 25.8 mg/L sebagai CO_2, dan mempunyai pH of 7.07.*

   (100 markah)

2. *Satu unit "rapid-mix" perlu direka untuk air mentah sebanyak 50,000-m^3/hari. Dengan menggunakan masa retensi selama 30s, tentukan saiz tangki V dan kuasa motor pengkacau R_i tersebut. Anggap keefisienan aci-enjin h dan motor M adalah 75% dan 90% masing masing serta suhu air adalah 20 °C.*

   Diberi:

$$G = \sqrt{\frac{P_f}{\mu \forall}}$$

   $\mu = 10(10^{-4})$ *kg/ms*
   $R_i = R_f / \ h \ M$
   $G = 800\ s^{-1}$
   One hp = 745.7 Watts

   (100 markah)

3. *Masa pemendapan (retensi) bagi satu tangki prototaip dan kadar limpah ialah 44 min dan 0.10m/min masing-masing. Rancangkan suatu tangki pengendap segiempat tepat dengan menggunakan nilai-nilai yang diberi untuk kadar aliran sebanyak 20 000 m^3/hari.*

   Diberi:

$$Z_0 = \upsilon_0 t_0 \qquad\qquad \frac{Z_0}{\upsilon_0} = \frac{W Z_0 L}{Q}$$

   u_h *= halaju mendatar =0.8m/h*

   (100 markah)

4. *Air mentah yang perlu dirawat melalui proses lime-soda untuk mengurangkan kekerasannya mempunyai sifat-sifat berikut: CO_2=22.0mg/l, Ca^{2+}=80mg/L, Mg^{2+}=12.0mg/L, Na^{+}= 46.0mg/l, HCO_3^{-} = 152.5 mg/L and SO_4^{2-}=216.0mg/L.*

   (a) *Tentukan sama ada nombor imbangan ion positif dan negative adalah seimbang.*

   (50 markah)

   (b) *Bagi kadar 25, 000 m^3/hari, kirakan keperluan kimia dan berat pepejal serta isipadu endapan (sludge) yang dihasilkan.*

   Anggap bahawa kapur yang digunakan adalah 90% tulen dan soda ash yang digunakan adalah 85% tulen. Anggap graviti spesifik endapan (sludge) adalah 1.04

   C = 12, O = 16, Ca = 40, Mg = 24, Na = 23, H = 1.0, S = 32.

   For CO_2: CO2 + CaO + H2O → $CaCO_3$ + H_2O

   For $Mg(HCO_3)_2$: $Mg(HCO_3)_2$ + 2CaO + $2H_2O$ → $Mg(OH)_2$ + $2CaCO_3$ + $2H_2O$

   For $Ca(HCO_3)_2$: $Ca(HCO_3)_2$ + CaO + H2O → $2CaCO_3$ + H_2O

   For $CaSO_4$: $CaSO_4$ + Na_2CO_3 → CaCO3 + Na_2SO_4

   (50 markah)

5. *Satu loji rawatan air telah direkabentuk untuk memproses 50,000 m^3/d air. 'Jar test' dan 'pilot plant analysis' mendapati bahawa dos alum sebanyak 40 mg/L penggumpalan pada nilai Gt 4.0 x 10^4 menghasilkan keputusan optimum pada anggaran suhu air 15°C.*

   Tentukan:

   (a) *Keperluan alum dalam sebulan.*

   (b) *Dimensi tangki penggumpalan jika tiga palang padel aliran melintang digunakan. Alat penggumpal tersebut perlu bersaiz maksimum 12 m lebar dan 5 m dalam supaya sesuai disambungkan dengan tangki pemendakan.*

(c) Kuasa yang diperlukan.

$$D = C_D A_P \rho \frac{\upsilon_P^2}{2}$$

C_D = dimensionless coefficient of drag, 1.8 for flat blades

A_P = area of paddle blades, m^2

ρ = density of water, kg/m^3

$$P = \frac{C_D A_P \rho \upsilon_P^3}{2}$$

$$G = \left(\frac{C_D A_P \rho \upsilon_P^3}{2V\mu} \right)^{1/2}$$

(100 markah)