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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]*

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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.]*

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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<sub>3</sub>, alkalinity of 185 mg/L as CaCO<sub>3</sub>, Mg<sup>2+</sup> 15.8 mg/L as Mg<sup>2+</sup>, Na<sup>+</sup> 8 mg/L as Na<sup>+</sup>, SO<sub>4</sub><sup>2-</sup> 28.6 mg/L as SO<sub>4</sub><sup>2-</sup>, Cl<sup>-</sup> 10.0 mg/L as Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup> 1.0 mg/L as N, CO<sub>2</sub> 25.8 mg/L as CO<sub>2</sub>, and has a pH of 7.07.

(100 marks)

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

Given:

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

$$\mu = 10(10^{-4}) \text{ kg/ms}$$

$$R_i = R_f / h M$$

$$G = 800 \text{ s}^{-1}$$

$$\text{One hp} = 745.7 \text{ Watts}$$

(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<sup>3</sup>/d.

Given:

$$Z_0 = v_0 t_0$$

$$\frac{Z_0}{v_0} = \frac{WZ_0L}{Q}$$

$$u_h = \text{horizontal velocity} = 0.8\text{m/h}$$

(100 marks)

4. A raw water to be treated by the lime-soda process to the minimum hardness possible has the following characteristics:  $\text{CO}_2=22.0\text{mg/l}$ ,  $\text{Ca}^{2+}=80\text{mg/L}$ ,  $\text{Mg}^{2+}=12.0\text{mg/L}$ ,  $\text{Na}^+=46.0\text{mg/l}$ ,  $\text{HCO}_3^- = 152.5 \text{ mg/L}$  and  $\text{SO}_4^{2-}=216.0\text{mg/L}$ .

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

(50 marks)

- (b) For a flow of 25, 000  $\text{m}^3/\text{day}$ , 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, Mg = 24, Na = 23, H = 1.0, S = 32.

For  $\text{CO}_2$ :  $\text{CO}_2 + \text{CaO} + \text{H}_2\text{O} \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

For  $\text{Mg}(\text{HCO}_3)_2$ :  $\text{Mg}(\text{HCO}_3)_2 + 2\text{CaO} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + 2\text{CaCO}_3 + 2\text{H}_2\text{O}$

For  $\text{Ca}(\text{HCO}_3)_2$ :  $\text{Ca}(\text{HCO}_3)_2 + \text{CaO} + \text{H}_2\text{O} \rightarrow 2\text{CaCO}_3 + \text{H}_2\text{O}$

For  $\text{CaSO}_4$ :  $\text{CaSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + \text{Na}_2\text{SO}_4$

(50 marks)

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

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.

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

$C_D$  = dimensionless coefficient of drag, 1.8 for flat blades

$A_P$  = area of paddle blades, m<sup>2</sup>

$\rho$  = density of water, kg/m<sup>3</sup>

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

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

(100 marks)

1. Kira jumlah kapur dan serbuk soda yang diperlukan untuk melembutkan air yang mengandungi jumlah kekerasan 215 mg/L  $\text{CaCO}_3$ , kealkalian 185 mg/L  $\text{CaCO}_3$ ,  $\text{Mg}^{2+}$  15.8 mg/L sebagai  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  8 mg/L sebagai  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$  28.6 mg/L sebagai  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$  10.0 mg/L sebagai  $\text{Cl}^-$ ,  $\text{NO}_3^-$  1.0 mg/L sebagai N,  $\text{CO}_2$  25.8 mg/L sebagai  $\text{CO}_2$ , dan mempunyai pH of 7.07.

(100 markah)

2. Satu unit "rapid-mix" perlu direka untuk air mentah sebanyak 50,000- $\text{m}^3$ /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:

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

$$\mu = 10(10^{-4}) \text{ kg/ms}$$

$$R_i = R_f / h \quad M$$

$$G = 800 \text{ s}^{-1}$$

$$\text{One hp} = 745.7 \text{ Watts}$$

(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  $\text{m}^3$ /hari.

Diberi:

$$Z_0 = u_h t_0$$

$$\frac{Z_0}{v_0} = \frac{W Z_0 L}{Q}$$

$$u_h = \text{halaju mendatar} = 0.8 \text{ m/h}$$

(100 markah)

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

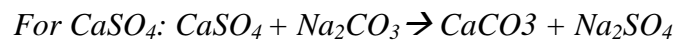
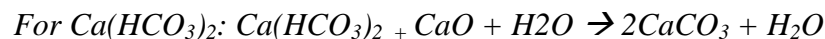
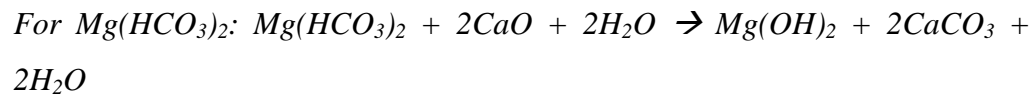
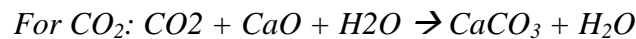
(a) Tentukan sama ada nombor imbalan ion positif dan negative adalah seimbang.

(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

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



(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  $Gt = 4.0 \times 10^4$  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.*

$$D = C_D A_p \rho \frac{v_p^2}{2}$$

$C_D$  = dimensionless coefficient of drag, 1.8 for flat blades

$A_p$  = area of paddle blades, m<sup>2</sup>

$\rho$  = density of water, kg/m<sup>3</sup>

$$P = \frac{C_D A_p \rho v_p^3}{2}$$

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

(100 markah)