
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.]

1. Calculate the necessary amounts of lime and soda ash to soften a water which contains a total hardness of 215 mg/L as CaCO₃, alkalinity of 185 mg/L as CaCO₃, Mg²⁺ 15.8 mg/L as Mg²⁺, Na⁺ 8 mg/L as Na⁺, SO₄²⁻ 28.6 mg/L as SO₄²⁻, Cl⁻ 10.0 mg/L as Cl⁻, NO₃⁻ 1.0 mg/L as N, CO₂ 25.8 mg/L as CO₂, and has a pH of 7.07.

(100 marks)

2. A rapid-mix unit is to be designed for 50,000-m³/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:

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

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

$$R_i = R_f / h \ M$$

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

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

(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 m³/d.

Given:

$$Z_0 = v_0 t_0$$

$$\frac{Z_0}{v_0} = \frac{WZ_0 L}{Q}$$

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

(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 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, Mg = 24, Na = 23, H = 1.0, S = 32.

For 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 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 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 4.0×10^4 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.

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

C_D = dimension less coefficient of drag, 1.8 for flat blades

A_P = area of paddle blades, m²

ρ = density of water, kg/m³

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

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

(100 marks)

1. Kira jumlah kapur dan serbuk soda yang diperlukan untuk melembutkan air yang mengandungi jumlah kekerasan 215 mg/L 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 η dan motor M adalah 75% dan 90% masing masing serta suhu air adalah 20 °C.

Diberi:

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

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

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

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

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

(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 m^3 /hari.

Diberi:

$$Z_0 = v_0 t_0$$

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

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

(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 $SO_4^{2-}=216.0\text{mg/L}$.

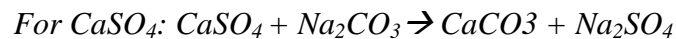
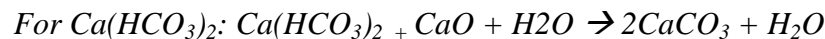
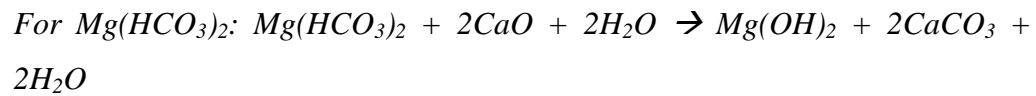
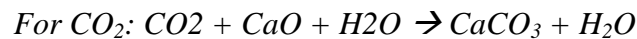
(a) Tentukan sama ada nombor imbalan ion positif dan negative adalah seimbang.

(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, m²

ρ = density of water, kg/m³

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

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

(100 markah)