UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2004/2005

October 2004

IEK 305E – Equipment Design in Water Treatment
[Rekabentuk Peralatan Pengolahan Air]

Duration : 3 hours

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

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LAPAN mukasurat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer FIVE questions. Answer all questions in English OR Bahasa Malaysia OR combination of both.

*[**Arahan**: Jawab LIMA soalan. Semua soalan boleh dijawab dalam Bahasa Inggeris ATAU Bahasa Malaysia ATAU kedua-duanya.]*

1. (a) Discuss TWO chemical methods in water treatment.

(50 marks)

(b) Discuss particle removal by flotation processes.

(50 marks)

1. (a) Bincangkan DUA kaedah kimia dalam pengolahan air.

(50 markah)

(b) Bincangkan pemecatan zarah melalui proses pengapungan.

(50 markah)

2. With the help of flow diagram, discuss various treatment systems involved in water processing for both surface water and groundwater.

(100 marks)

2. Dengan bantuan gambarajah aliran, bincangkan berbagai sistem pengolahan yang melibatkan pemprosesan air untuk air permukaan dan air bumi.

(100 markah)

3. (a) Discuss aerobic water treatment process.

(25 marks)

(b) Discuss sequencing batch reactor used in water treatment.

(25 marks)

(c) A filter cake containing 30 % water is fed to a rotary dryer to be dewatered. After 600 kg of water has been removed in the drying operation, the dried sludge is found to contain 20 % water. What is the weight of the filter cake fed to the dryer ?

(50 marks)

3. (a) *Bincangkan tentang proses pengolahan air secara aerobik.*

(25 markah)

(b) *Bincangkan reaktor kelompok penjujukan dalam pengolahan air.*

(25 markah)

(c) *Satu kek turas yang mengandungi 30 % air dimasukkan ke dalam satu pengering putaran untuk dinyahairkan. Selepas 600 kg air telah disingkirkan dalam operasi pengeringan tersebut, enapcemar terkering itu didapati mengandungi 20 % air. Apakah beratnya kek turas yang dimasuki pengering itu ?*

(50 markah)

4. (a) 1 L of wastewater contains 10 mg of Pb(II). Alum [$Al_2(SO_4)_3$] is used as the coagulant to treat the wastewater. The removal efficiency of Pb(II) is found to be 97 %. The optimal alum dosage used is 1.2 g/L wastewater. The coagulant aid used for bridging the flocs is 0.0003 g. The reaction involved is

$$Al_2(SO_4)_3 + 6\,NaOH \rightarrow 2\,Al(OH)_3 + 3Na_2SO_4$$

Mol. Wt.: $Al_2(SO_4)_3$ = 594.36, $Al(OH)_3$ = 78.0

Assuming that Pb(II) ions are adsorbed onto the amorphous precipitates [$Al(OH)_3$] and that Na_2SO_4 does not precipitate, calculate the theoretical weight of the sludge formed, in g/L wastewater.

(70 marks)

(b) How many kg of pure sodium hydroxide are required to neutralize and industrial wastewater with an acidity equivalent to 80 kg of sulfuric acid per million litre of wastewater ?

Mol. Wt.: NaOH = 40.0, H_2SO_4 = 98.1

(30 marks)

...4/-

4. (a) *1 L air sisa mengandungi 10 mg Pb(II). Alum [$Al_2(SO_4)_3$] digunakan sebagai bahan pengental untuk mengolahkan air sisa tersebut. Keefisienan pemecatan Pb(II) ialah 97 %. Dos alum optimum ialah 1.2 g/L air sisa. Bahan pembantu pengental yang digunakan untuk membesarkan flok ialah 0.0003 g. Tindak balas kimia terlibat ialah*

$$Al_2(SO_4)_3 + 6\,NaOH \rightarrow 2\,Al(OH)_3 + 3Na_2SO_4$$

Mol. Wt.: $Al_2(SO_4)_3 = 594.36,\ Al(OH)_3 = 78.0$

Dengan menganggapkan bahawa ion Pb(II) dijerapkan di atas mendakan amorfus [$Al(OH)_3$] dan Na_2SO_4 tidak memendak, hitungkan berat teoretis enapcemar terbentuk, dalam unit g/L air sisa.

(70 markah)

(b) *Berapa kg natrium hidroksida tulen diperlukan untuk meneutralkan satu air sisa industri yang mempunyai keasidan yang setara dengan 80 kg asid sulfuric per juta liter air sisa ?*

Mol. Wt.: $NaOH = 40.0,\quad H_2SO_4 = 98.1$

(30 markah)

5. (a) Determine the size (diameter of cylinder) of two identical circular final clarifiers for an activated sludge system with a design flow of 21,000 m^3/d with a peak hour flow of 32,000 m^3/d. Use maximum overflow rates of 33 $m^3/m^2.d$ at design flow and 66 $m^3/m^2.d$ at peak hourly flow.

(50 marks)

(b) Spherical sand particles of diameter 0.01 mm and density 2650 kg/m^3 are to be removed in an ideal, horizontal-flow, settling basin 3 m deep with a surface area of 900 m^2. If the flow is 81,000 m^3/d and the water temperature is 20 °C ($\mu = 1.0 \times 10^{-3}$ kg/m.s, $\rho = 1000\ kg/m^3$), calculate the terminal velocity of the particles and the overflow velocity.

Assume Stokes Law:

$$u_t = (\rho_p - \rho) g D_p^2 / 18\mu$$

(50 marks)

5. (a) *Tentukan saiz (diameter silinder) dua penjernih akhir bersilinder yang sama untuk satu system enapcemar teraktif dengan aliran rekabentuk 21,000 m^3/hari dan aliran sejam puncak 32,000 m^3/hari. Gunakan kadar aliran limpah maksimum 33 m^3/m^2.hari untuk aliran rekabentuk dan 66 m^3/m^2.hari pada aliram sejam puncak.*

(50 markah)

(b) *Zarah pasir sfera yang berdiameter 0.01 mm dan ketumpatan 2650 kg/m^3 akan disingkirkan dari satu basin pemendak aliran-mendatar dan unggul yang mempunyai kedalaman 3 m dan luas permukaan 900 m^2. Jika kadar aliran ialah 81,000 m^3/hari dan suhu air ialah 20 °C ((μ = 1.0 x 10^{-3} kg/m.s, ρ = 1000 kg/m^3), hitungkan halaju terminal zarah dan halaju aliran limpah. Anggap hukum Stokes:*

$$u_t = (\rho_p - \rho) g D_p^2 / 18\mu$$

(50 markah)

6. A sludge containing 30,000 mg solids/L is sent at a rate of 120 kg solids/d to a gravity thickener which can achieve an underflow concentration of 8 % and then the sludge is further concentrated in a vacuum filter that removes 75 % of the water from the feed stream as shown in the following diagram. The density of the wet sludge can be taken as that of water. Calculate

(a) the flowrate of thickened sludge

(b) the composition of the filter cake

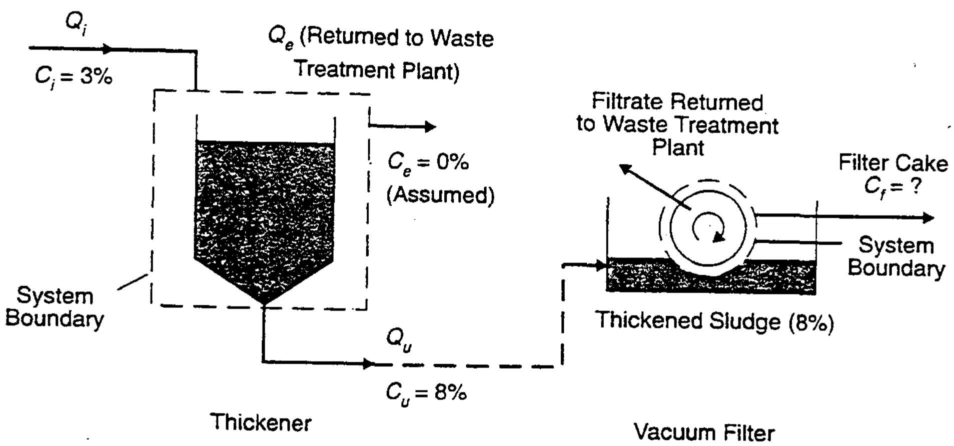
(100 marks)

6. *Suatu enapcemar yang mengandungi 30,000 mg pepejal/L adalah dihantarkan pada kadar 120 kg pepejal/hari ke dalam satu pemekat graviti yang boleh mencapai kepekatan saluran bawah 8 % dan kemudian enapcemar dipekatkan selanjutnya di dalam satu penuras vakum yang menyingkirkan 75 % air dari arus suap seperti ditunjukkan di gambarajah berikut. Ketumpatan enapcemar basah boleh dianggap bersamaan dengan ketumpatan air. Hitungkan*

   (a) *kadar aliran enapcemar terpekat*

   (b) *komposisi kek turas*

(100 markah)



CONVERSION FACTORS AND CONSTANTS OF NATURE

To convert from	To	Multiply by†
acre	ft^2	43,560*
	m^2	4046.85
atm	N/m^2	$1.01325^* \times 10^5$
	$lb_f/in.^2$	14.696
Avogadro number	particles/g mol	6.022169×10^{23}
barrel (petroleum)	ft^3	5.6146
	gal (U.S.)	42*
	m^3	0.15899
bar	N/m^2	$1^* \times 10^5$
	$lb_f/in.^2$	14.504
Boltzmann constant	J/K	1.380622×10^{-23}
Btu	cal_{IT}	251.996
	$ft\text{-}lb_f$	778.17
	J	1055.06
	kWh	2.9307×10^{-4}
Btu/lb	cal_{IT}/g	0.55556
Btu/lb-°F	cal_{IT}/g-°C	1*
Btu/ft^2-h	W/m^2	3.1546
Btu/ft^2-h-°F	W/m^2-°C	5.6783
	$kcal/m^2$-h-K	4.882
$Btu\text{-}ft/ft^2$-h-°F	$W\text{-}m/m^2$-°C	1.73073
	kcal/m-h-K	1.488
cal_{IT}	Btu	3.9683×10^{-3}
	$ft\text{-}lb_f$	3.0873
	J	4.1868*
cal	J	4.184*
cm	in.	0.39370
	ft	0.0328084
cm^3	ft^3	3.531467×10^{-5}
	gal (U.S)	2.64172×10^{-4}
cP (centipoise)	kg/m-s	$1^* \times 10^{-3}$
	lb/ft-h	2.4191
	lb/ft-s	6.7197×10^{-4}
cSt (centistoke)	m^2/s	$1^* \times 10^{-6}$
faraday	C/g mol	9.648670×10^4
ft	m	0.3048*
$ft\text{-}lb_f$	Btu	1.2851×10^{-3}
	cal_{IT}	0.32383
	J	1.35582
$ft\text{-}lb_f/s$	Btu/h	4.6262
	hp	1.81818×10^{-3}
ft^2/h	m^2/s	2.581×10^{-5}
	cm^2/s	0.2581
ft^3	cm^3	2.8316839×10^4
	gal (U.S.)	7.48052
	L	28.31684
ft^3-atm	Btu	2.71948
	cal_{IT}	685.29
	J	2.8692×10^3
ft^3/s	gal (U.S)/min	448.83
gal (U.S.)	ft^3	0.13368
	$in.^3$	231*
gravitational constant	$N\text{-}m^2/kg^2$	6.673×10^{-11}
gravity acceleration, standard	m/s^2	9.80665*
h	min	60*
	s	3600*
hp	Btu/h	2544.43
	kW	0.74624
hp/1000 gal	kW/m^3	0.197
in.	cm	2.54*
$in.^3$	cm^3	16.3871
J	erg	$1^* \times 10^7$
	$ft\text{-}lb_f$	0.73756
kg	lb	2.20462
kWh	Btu	3412.1
L	m^3	$1^* \times 10^{-3}$
lb	kg	0.45359237*
lb/ft^3	kg/m^3	16.018
	g/cm^3	0.016018
$lb_f/in.^2$	N/m^2	6.89473×10^3
lb mol/ft^2-h	kg mol/m^2-s	1.3562×10^{-3}
	g mol/cm^2-s	1.3562×10^{-4}
light, speed of	m/s	2.997925×10^8
m	ft	3.280840
	in.	39.3701
m^3	ft^3	35.3147
	gal (U.S.)	264.17
N	dyn	$1^* \times 10^5$
	lb_f	0.22481
N/m^2	$lb_f/in.^2$	1.4498×10^{-4}
Planck constant	J-s	6.626196×10^{-34}
proof (U.S.)	percent alcohol by volume	0.5
ton (long)	kg	1016
	lb	2240*
ton (short)	lb	2000*
ton (metric)	kg	1000*
	lb	2204.6
yd	ft	3*
	m	0.9144*

† Values that end in an asterisk are exact, by definition.

PROPERTIES OF LIQUID WATER

Temperature T, °F	Viscosity† μ', cP	Thermal conductivity‡ k, Btu/ft-h-°F	Density§ ρ, lb/ft³	$\psi_f = \left(\frac{k^3\rho^2 g}{\mu^2}\right)^{1/3}$
32	1.794	0.320	62.42	1,410
40	1.546	0.326	62.43	1,590
50	1.310	0.333	62.42	1,810
60	1.129	0.340	62.37	2,050
70	0.982	0.346	62.30	2,290
80	0.862	0.352	62.22	2,530
90	0.764	0.358	62.11	2,780
100	0.682	0.362	62.00	3,020
120	0.559	0.371	61.71	3,530
140	0.470	0.378	61.38	4,030
160	0.401	0.384	61.00	4,530
180	0.347	0.388	60.58	5,020
200	0.305	0.392	60.13	5,500
220	0.270	0.394	59.63	5,960
240	0.242	0.396	59.10	6,420
260	0.218	0.396	58.53	6,830
280	0.199	0.396	57.94	7,210
300	0.185	0.396	57.31	7,510

† From *International Critical Tables*, vol. 5, McGraw-Hill Book Company, New York, 1929, p. 10.
‡ From E. Schmidt and W. Sellschopp, *Forsch. Geb. Ingenieurw.*, 3:277 (1932).
§ Calculated from J. H. Keenan and F. G. Keyes, *Thermodynamic Properties of Steam*, John Wiley & Sons., Inc., New York, 1937.

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