UNIVERSITI SAINS MALAYSIA

First Semester Examination
2009/2010 Academic Session

November 2009

EKC 474 – Industrial Effluent Engineering
[Kejuruteraan Efluen Industri]

Duration : 3 hours
[Masa : 3 jam]

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

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

Instructions: Answer **FOUR** (4) questions. Section A is **COMPULSORY.** Answer any **TWO** (2) questions from Section B. All questions carry the same marks.

*[**Arahan:** Jawab **EMPAT** (4) soalan. Bahagian A **WAJIB** dijawab. Bahagian B pilih **DUA** (2) soalan sahaja. Semua soalan membawa jumlah markah yang sama.]*

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].

Write your index number in the space provided on the question paper. You are NOT ALLOWED to take the question paper out of the examination hall.

[Tulis nombor angka giliran dalam ruangan yang disediakan pada kertas soalan. Anda TIDAK DIBENARKAN membawa keluar kertas soalan dari dewan peperiksaan.]

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Section A : Answer ALL questions.
Bahagian A : Jawab SEMUA soalan.

1. [a] Propose integrated physical and chemical treatment units to be involved in a complete wastewater treatment plant to treat an industrial wastewater with characteristics below. Your answer should be assisted by a schematic diagram showing the units involved in a proper arrangement and justifications to your selection of process.

Cadangkan unit-unit rawatan fizikal dan kimia bersepadu yang perlu digunakan dalam loji rawatan air sisa lengkap bagi merawat air sisa industri dengan ciri-ciri seperti di bawah. Jawapan anda perlu dibantu dengan gambarajah berskema menunjukkan unit-unit yang terlibat dalam susunan yang sesuai dan kewajaran bagi proses pilihan anda.

Characteristics *Ciri-ciri*	Value *Nilai*
Flow rate, m^3/day *Kadar alir, m^3/hari*	1.3
O&G, mg/L	10
COD, mg/L	345
SS, mg/L	230
Cr, hexavalent, mg/L *Cr, heksavalen mg/L*	120
Cr, trivalent, mg/L *Cr, trivalen, mg/L*	56
pH	3.2

[8 marks/markah]

[b] List the important aspects to be determined when designing a chemical coagulation-flocculation unit for an industrial wastewater treatment system.

Senaraikan aspek-aspek penting yang perlu ditentukan apabila merekabentuk unit penggumpalan-pengelompokan kimia bagi sesebuah sistem rawatan air sisa industri.

[7 marks/markah]

[c] An electronic industry discharges its wastewater at a flow rate of 10 m^3/h. The wastewater is known to contain 120 mg/L of hexavalent chromium, 50 mg/L of trivalent chromium, 90 mg/L of zinc and 4 mg/L of dissolved oxygen. The removal of these metals is to be achieved by chemical precipitation method with the addition of lime ($Ca(OH)_2$) but the hexavalent chromium ion must be reduced by sulfur dioxide (SO_2) prior to the precipitation process. Determine:

Sebuah industri elektronik menyingkirkan air sisanya pada kadar alir 10m^3/j. Air sisa tersebut diketahui mengandungi 120 mg/L kromium heksavalen, 50 mg/L kromium trivalen, 90 mg/L zink dan 4 mg/L oksigen terlarut. Penyingkiran logam-logam ini akan dicapai menerusi kaedah pemendakan kimia dengan kapur ($Ca(OH)_2$) tetapi ion kromium heksavalen perlu diturunkan dengan sulfur dioksida (SO_2) sebelum proses pemendakan tersebut. Tentukan:

[i] The daily usage of SO_2 if the SO_2 requirements are 1.85 ppm and 4 ppm of SO_2 for each ppm of chromium and dissolved oxygen, respectively.

Kegunaan harian SO_2 jika keperluan SO_2 adalah 1.85 ppm dan 4 ppm bagi setiap ppm kromium dan oksigen terlarut, masing-masing.

[8 marks/markah]

[ii] The daily usage of $Ca(OH)_2$ if its requirements are 2.38 ppm and 1.30 ppm of $Ca(OH)_2$ for every ppm of chromium and zinc, respectively.

Kegunaan harian $Ca(OH)_2$ jika keperluannya adalah 2.38 ppm dan 1.30 ppm $Ca(OH)_2$ bagi setiap ppm kromium dan zink, masing-masing.

[7 marks/markah]

2. [a] Explain the following terms commonly associated with biological wastewater treatment systems:

Jelaskan istilah-istilah berikut yang berkaitan dengan sistem rawatan biologi air sisa:

[i] cryptic growth
pertumbuhan kriptik

[ii] washout
basuh-habis

[iii] anoxic
anosik

[6 marks/markah]

[b] [i] List two disadvantages of using aerobic method for treatment of food processing wastewater with the following composition.

Senaraikan dua keburukan penggunaan kaedah aerobik untuk rawatan air sisa pemprosesan makanan dengan komposisi berikut.

Component *Komponen*	Value *Nilai*
pH	4.0 - 4.5
COD	1500 – 7000 mg/L
BOD	900 – 6000 mg/L

[ii] Propose a suitable biological treatment arrangement for the above wastewater.

Cadangkan aturan rawatan biologi yang sesuai bagi air sisa tersebut.

[6 marks/markah]

[c] Parameter values for a particular anaerobic treatment system are as follow:

Nilai-nilai parameter bagi sebuah sistem rawatan anaerob adalah seperti berikut:

Half saturation constant, K_s, gCOD/L *Pemalar ketepuan separuh, K_s* gCOD/L	1.8 [1.112 $^{(T-35)}$]
Maximum specific growth rate, μ_{max},1/day *Kadar pertumbuhan spesifik maksimum, μ_{max}* 1/hari	0.27 [1.035 $^{(T-35)}$]
Maximum specific substrate uptake rate, *k*, 1/day *Kadar pengambilan substrat spesifik maksimum, k* 1/hari	6.67 [1.035 $^{(T-35)}$]
Endogenous respiration rate, k_d, 1/day *Kadar respirasi endogenous, k_d*, 1/hari	0.03 [1.035 $^{(T-35)}$]
Cell yield, *Y*, g VSS/g COD *Hasil sel, Y*, g VSS/g COD	0.04

If the process safety factor (SF) is 10, and the system operates at 35°C, calculate the design solid retention time (SRT).

Faktor keselamatan proses (SF) ialah 10, dan sistem tersebut beroperasi pada 35°C. Kirakan masa penahanan pepejal (SRT) rekabentuk.

What is the new process SF, if the temperature of the system drops to 20°C and the design SRT remains the same?

Apakah SF proses baru sekiranya suhu sistem tersebut jatuh kepada 20°C dan SRT rekabentuk kekal sama?

Useful relations: *Persamaan:* $$\mu = \frac{r_g}{X} = Y\frac{kS}{K_s+S} - k_d$$

[8 marks/markah]

[d] It is a common practice to use "selectors" to control sludge foaming in activated sludge treatment systems. The selectors are typically created in one or more tanks prior to the aeration tank as shown in Figure Q.2.[d]. Suggest three conditions that could be created in a "selector" to achieve floc-foaming bacteria over filamentous bacteria. Justify your suggestions.

Penggunaan "pemilih" menjadi amalan lazim untuk mengawal enapcemar berbuih di sistem rawatan enapcemar teraktif. "Pemilih" tersebut kebiasaannya diwujudkan satu atau dua tangki sebelum tangki pengudaraan seperti di Rajah S2. Cadangkan tiga keadaan yang mungkin diwujudkan dalam "pemilih" untuk menghasilkan bakteria berbuku berbanding bakteria berfilamen. Berikan justifikasi bagi cadangan anda.

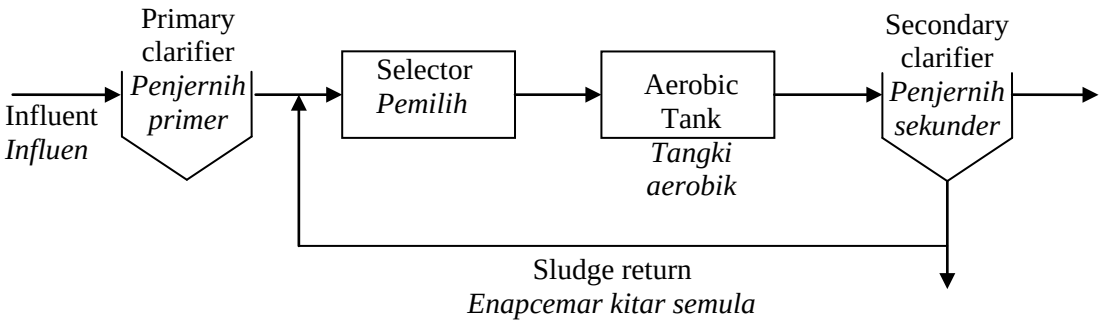

Figure Q.2.[d].
Rajah S.2.[d].

[6 marks/markah]

[e] Why it is difficult to develop an accurate and a comprehensive mathematical model for biofilm processes involved in wastewater treatments?

Mengapakah ianya sukar untuk menghasilkan model matematik yang jitu dan menyeluruh bagi proses biofilem yang terlibat dalam rawatan air sisa.

[4 marks/markah]

Section B : Answer any TWO questions.
Bahagian B : Jawab mana-mana DUA soalan.

3. [a] [i] List 5 common differences between the roles of wastewater treatment units categorized under primary and secondary treatment processes.

Senaraikan 5 perbezaan lazim antara peranan unit rawatan air sisa yang dikategorikan sebagai proses primer dan sekunder.

[5 marks/markah]

[ii] A 20 m diameter clarifier for an industrial wastewater treatment plant processes an average flow of 7,570 m^3/day of wastewater. If the ratio of the peak hourly flow to the average hourly flow is 2.8, determine the peak weir loading of the clarifier's peripheral weir.

Sebuah penjernih berdiameter 20 m bagi sebuah loji rawatan air sisa industri memproses air sisa pada kadar alir purata 7,570 m^3/hari. Sekiranya nisbah aliran per jam puncak terhadap aliran purata ialah 2.8, tentukan bebanan empang limpah puncak bagi empang limpah penjernih.

[5 marks/markah]

[b] [i] Give two primary sources of sulfur and explain how they are converted into hydrogen sulphide (H_2S) in sewage systems. Explain why H_2S generation can be a problem in sewerage systems.

Berikan dua punca utama sulfur dan jelaskan bagaimana ia ditukarkan kepada hidrogen sulfida (H_2S) dalam sistem kumbahan. Seterusnya jelaskan mengapa penghasilan H_2S boleh menimbulkan masalah di dalam sistem kumbahan.

[ii] Briefly explain how you would minimize the generation of H_2S and its impact on a sewerage system.

Jelaskan secara ringkas bagaimana anda akan meminimumkan penghasilkan H_2S dan kesan H_2S terhadap sistem kumbahan.

[10 marks/markah]

4. [a] [i] Heavy metals can be removed from wastewater using a suitable chemical precipitation method. Figure Q.4.[a].[i]. shows plots of heavy metal solubility as their hydroxides and sulfides as a function of pH. Provide comments on the removal of lead using these two chemical precipitation methods on the basis of its suitability, effluent quality and difficulty in the control of the process.

Logam-logam berat boleh disingkirkan dari air sisa menggunakan kaedah pemendakan kimia yang sesuai. Rajah S.4.[a].[i]. menunjukkan plot-plot keterlarutan logam berat sebagai hidroksida dan sulfida sebagai fungsi pH. Berikan komen bagi penyingkiran plumbum menggunakan kedua-dua kaedah pemendakan kimia ini berdasarkan kesesuaian, kualiti efluen, dan kesukaran dalam kawalan proses.

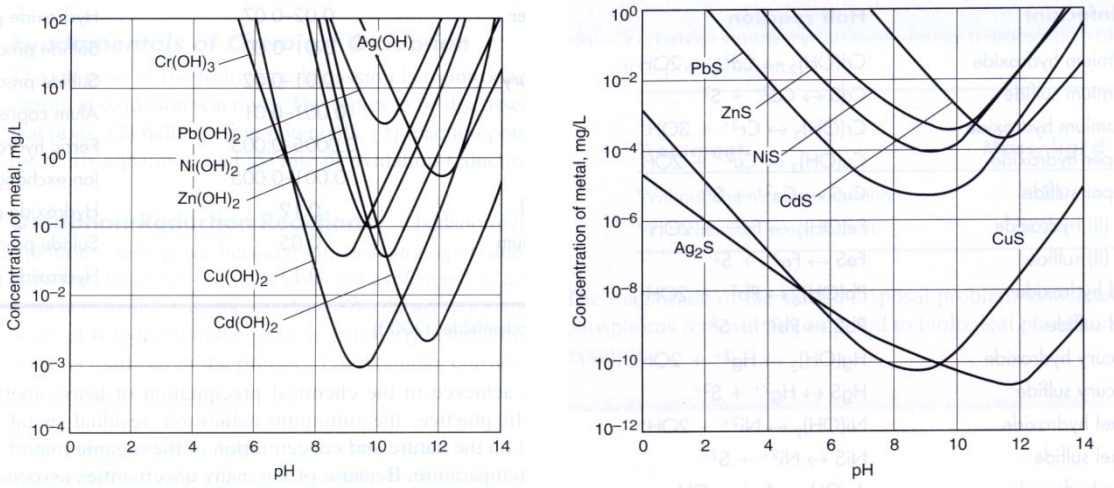

Figure Q.4.[a].[i]
Rajah S.4.[a].[i]

[10 marks/markah]

[b] For each of the following changes in an A^2O system (biological phosphorus removal system), state whether the phosphorus concentration in the effluent of the system will increase, decrease or remain the same. Briefly explain your answer:

Bagi setiap perubahan di dalam sistem A^2O (sistem penyingkiran biologi fosforus) nyatakan samada kepekatan fosforus dalam efluen sistem tersebut akan meningkat, menurun atau kekal sama. Jelaskan secara ringkas jawapan anda.

[i] The retention time in anaerobic stage is increased.
Masa penahanan peringkat anaerob ditingkatkan.

[ii] The operation staff decided to include an extra internal recycle from anoxic stage to anaerobic stage.

Staf operasi memutuskan untuk menambah satu lagi kitar semula dalaman dari peringkat anosik ke peringkat anaerob.

[iii] Return activated sludge recycle entering anaerobic stage contains higher nitrate concentration.

Kitar semula enapcemar teraktif yang memasuki peringkat anaerob mengandungi kepekatan nitrat yang tinggi.

[iv] Return activated sludge is recycled to anoxic stage instead of the anaerobic stage.

Enapcemar teraktif dikitar semula ke peringkat anosik dan bukannya ke peringkat anaerobik.

[10 marks/markah]

5. [a] A lab scale adsorption experiment is conducted to study the removal of congo red dye from an industrial wastewater using granular activated carbon (GAC). The adsorption process is known to follow the Freundlich isotherm. In every run, different amounts of GAC are contacted with 1 liter of wastewater and the equilibrium concentration is determined after no more change in concentration with time is observed. The data collected are given below.

Suatu eksperimen berskala makmal dijalankan untuk mengkaji penyingkiran pencelum kongo merah dari air sisa industri menggunakan karbon teraktif berbutir (GAC). Proses penjerapan tersebut diketahui mematuhi isoterma Freundlich. Bagi setiap experimen, amaun GAC yang berbeza dimasukkan ke dalam 1 liter air sisa dan kepekatan keseimbangan ditentukan selepas didapati tiada lagi perubahan dalam kepekatan. Data yang dikumpul diberikan di bawah.

GAC loading (mg GAC/L) *Bebanan GAC (mg GAC/L)*	Equilibrium concentration, C_e (mg/L) *Kepekatan keseimbangan C_e (mg/L)*
0.0	3.37
1.0	3.27
10.0	2.77
100.0	1.86
500.0	1.33

[i] Determine the Freundlich isotherm coefficients.
Tentukan pekali isoterma Freundlich.

[5 marks/markah]

[ii] A GAC contactor to treat the same wastewater to a final concentration of 0.80 mg/L is designed to have a cross sectional area of 0.93 m^2 with a depth of 1.52 m and the filtration rate desired is 0.20 m^3/m^2min. It is known that the density of the GAC used is 650 kg/m^3. Assuming the breakthrough adsorption capacity $(x/m)_b$ occurs at 50 % of the theoretical adsorption capacity, determine the breakthrough time for the adsorption system.

Suatu penyentuh GAC untuk merawat air sisa yang sama ke kepekatan akhir 0.80 mg/L direkabentuk untuk mempunyai luas keratan rentas 0.93 dengan kedalaman 1.52 m. Kadar penurasan yang dikehendaki ialah 0.20 m^3/m^2min. Diketahui bahawa ketumpatan GAC yang digunakan ialah 650 kg/m^3. Dengan menganggap bahawa kapasiti penjerapan bolos $(x/m)_b$ berlaku pada 50% kapasiti penjerapan teori, tentukan masa bolos bagi sistem penjerapan tersebut.

[5 marks/markah]

[b] [i] A lab scale sequencing batch reactor (SBR) operates with a cycle time of 6 hours to remove BOD in the influent. Each cycle consist of a 270 minutes aerobic feeding, 20 minutes aerobic reaction, 60 minutes settling and 10 minutes decanting period. The reactor has a working volume of 10 L and 2 L feed is being fed in each cycle. The biomass concentration in the reactor is stable and average to 720 mgMLSS/L. The sludge age is 3.0 days and 0.75 L biomass is being wasted in each cycle.

Sebuah reaktor kelompok berkitar (SBR) beroperasi dengan masa kitar 6 jam untuk menyingkirkan BOD dari influen. Setiap kitar terdiri daripada 270 minit penyuapan beraerob, 20 minit tindak balas beraerob, 60 minit pengenapan dan 10 minit pengeluaran. Reaktor tersebut mempunyai isipadu berfungsi 10 L dan 2 L suapan bagi setiap kitar. Kepekatan biojisim dalam reaktor adalah stabil dan nilai puratanya ialah 720 mg MLSS/L. Masa penahanan biomas ialah 3.0 hari dan 0.75 L biomas dikeluarkan bagi setiap kitar.

Suggest what modification could be done to upgrade the SBR to include nitrogen removal from the influent wastewater. Give reasons for your suggestions.

Cadangkan penyesuaian yang boleh dilakukan untuk menambahbaik SBR tersebut supaya nitrogen turut disingkirkan daripada air sisa influen. Berikan sebab-sebab bagi cadangan anda.

[5 marks/markah]

[ii] Figure Q.5.[b].[ii] shows schematic of a wastewater treatment system. Explain how nitrogen removal is achieved in this system. Propose a suitable effluent withdrawal point.

Rajah S.5.[b].[ii] menunjukkan skema sistem rawatan air sisa. Jelaskan bagaimana penyingkiran nitrogen dicapai dalam sistem ini. Cadangkan tempat pengeluaran efluen yang sesuai.

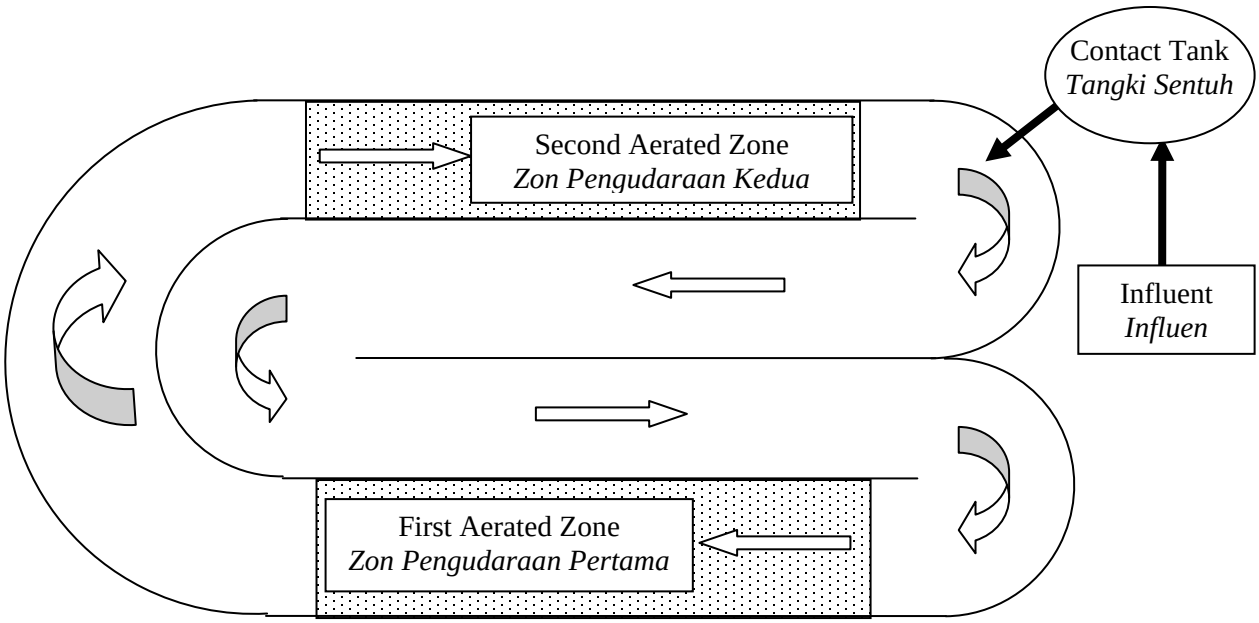

Figure Q.5.[b].[ii]
Rajah S.5.[b].[ii]

[5 marks/markah]

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