UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2003/2004

September/October 2003

IEK 309E – CHEMODYNAMICS

Time: 3 hours

Please check that the examination paper consists of TEN printed pages before you commence this examination.

Answer FIVE questions only. Students are allowed to answer all questions in English OR Bahasa Malaysia OR combinations of both.

1. A natural stream 0.8 m deep flows with an average velocity at 0.10 m/s. At a point where the waste outfall enters the stream after homogeneous mixing the concentration of the oxygen demanding organic materials is 30 mg/L. The oxygen demanding materials decays and utilizes oxygen according to the given equation ρ_{B2} at 0.5 per day;

$$\rho_{B2} = \rho_{B2}^{O} \exp(-k_B''' t^*)$$

$$\Delta_A^O = \rho_{A2}^* - \rho_{A2}^O$$

$$\Delta_A = \frac{k_B'' \rho_{B2}^O}{(k_{A2}^1 / h) - k_B''} \left[\exp(-k_B''' t) - \exp\left(\frac{-^1k_{A2} t}{h}\right) \right] + \Delta_A^o \exp\left(\frac{-^1k_{A2} t}{h}\right)$$

ρ_{A2}^* = 8.84 mg/l @ 20 °C

ϑ_{A2} =1.8 E-5 cm^2/s

$$t = \frac{L}{v_2}$$

Calculate what is the:

(a) Liquid mass transfer coefficient,

$$^1k_{A2} = (\vartheta_{A2} v_x / h)^{1/2}$$

(b) The dissolved oxygen concentration at 15 kilometers downstream if the after mixing homogeneous concentration at the outfall ρ_{A2}^O = 6 mg/L. Assume the stream water temperature is 20°C .

1. *Sebatang sungai semulajadi kedalamannya 0.8 m mengalir dengan kelajuan purata 0.10 m/s. Pada satu titik dimana terdapat satu titik punca yang mendiscas sisa kedalam sungai dimana didapati bahawa kepekatan oksigen setelah air bercampur secara homogen ialah 30 mg/L. Jika kadar reputan bahan sisa ialah 0.5 per hari dan keperluan oksigen bagi bahan sisa mereput mengikut persamaan seperti* ρ_{B2} *yang diberikan ;*

$$\rho_{B2} = \rho_{B2}^{O} \exp(-k_B''' t^*)$$

$$\Delta_A^O = \rho_{A2}^* - \rho_{A2}^O$$

$$\Delta_A = \frac{k_B''' \rho_{B2}^O}{({}^1k_{A2}/h) - k_B'''} \left[\exp(-k_B''' t) - \exp\left(\frac{-{}^1k_{A2} t}{h}\right) \right] + \Delta_A^o \exp\left(\frac{-{}^1k_{A2} t}{h}\right)$$

$\rho_{A2}^* = 8.84$ *mg/l @ 20 °C*

$\vartheta_{A2} = 1.8$ *E-5* cm^2/s

$$t = \frac{L}{v_2}$$

Kirakan berapakah:

(a) Koefisien pemindahan jisim fasa cecair

$$^1k_{A2} = (\vartheta_{A2} v_x / h)^{1/2}$$

(b) Kepekatan oksigen pada jarak 15 kilometer dari titek punca jika kepekatan oksigen pada titek punca percampuran ialah ρ_{A2}^O *= 6 mg/L. Anggapkan bahawa suhu air sungai ialah pada 20°C .*

(100 markah)

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2. Referring to the equation and data given in question 1 and base on the following given equations:

$$\Delta_A = \Delta_A^O$$

$\rho_{B2} - \rho_{B2}^O$ At t=0 at initial conditions;

$$t_c = \frac{1}{({}^1k_{A2}/h) - k_B^{'''}} \ln\left[\frac{{}^1k_{A2}}{hk_B^{'''}}\left(1 - \Delta_A^O\left(\frac{({}^1k_{A2}/h) - k_B^{'''}}{k_B^{'''}\rho_{B2}^O}\right)\right)\right]$$

Calculate what is:

(a) Concentration of the remaining waste in mg/L at the point mentioned in question 1 part a).

(b) The critical time t_c and distance in kilometer where the oxygen concentration is at a minimum level ?

(c) Show and express graphically the mentioned values.

2. *Berpandukan pada persamaan dan data yang di berikan dalam soalan 1 dan persamaan yang diberikan:*

$$\Delta_A = \Delta_A^O$$

$\rho_{B2} - \rho_{B2}^O$ *Bila t=0 sebagai situasi permulaan;*

$$t_c = \frac{1}{({}^1k_{A2}/h) - k_B^{'''}} \ln\left[\frac{{}^1k_{A2}}{hk_B^{'''}}\left(1 - \Delta_A^O\left(\frac{({}^1k_{A2}/h) - k_B^{'''}}{k_B^{'''}\rho_{B2}^O}\right)\right)\right]$$

Kirakan berapakah:

(a) Kepekatan baki bahan sisa dalam mg/L pada jarak yang seperti disebutkan pada soalan 1 bahagian a).

(b) *Masa kritikal t_c dan jarak dalam kilometer dimana kepekatan oksigen adalah pada tahap minima ?*

(c) *Lakarkan nilai nilai tersebut dalam bentuk gambarajah.*

(100 markah)

3. What is the hydraulic radius (r_h), the interfacial air-water per volume $^b a_v$ and average surface velocity (u_{av}) for the following condition where:

$$\text{Given : } u = \frac{1.49}{n} r_h^{2/3} S_0^{1/2}$$

Where :
U = velocity , mps
n= coefficient of friction , 0.03
r_h = hydraulic radius , A/P m
A =Cross Section area , m^2
P = wetted perimeter, m
S_o = slope m/m ($\leq 10^o$)

3. *Kirakan jejari hidraulik (r_h), luas antaramuka air-udara per isipadu $^b a_v$ dan purata halaju permukaan (u_{av}) untuk keadaan berikut dimana:*

Di beri bahawa: $u = \frac{1.49}{n} r_h^{2/3} S_0^{1/2}$

Di mana:
U = halaju, mps
n= koefisien geseran, 0.03
r_h = jejari hidraulik, A/P m
A =Luas x seksyen, m^2
P = perimeter basah, m
S_o =kecerunan m/m ($\leq 10^o$)

(a) The depth h of the river is 12 meter (maximum) and the length b is 40 meter.

(a) *Satu sungai yang mempunyai kedalaman h sebanyak 12 meter (maksimum) dan panjangnya b ialah 40 meter.*

(50 markah)

(b) A river having a triangular bottom shape an angle of 45° with depth h, 12 meter (maximum) and the bottom width b, 40 meter.

(b) Satu sungai yang berbentuk tigasegi bersudut 45° mempunyai kedalaman h, 12 meter (maksimum) dan lebar dasarnya, b 40 meter.

(50 markah)

4. (a) Derive the equation for the desorption process in a plug flow reactor (plug flow basin). Start the derivation based on the mass transfer of a species A. Refer to the given figure below.

Where:

h= depth of reactor

ω= width of reactor

X_A = molar average species A

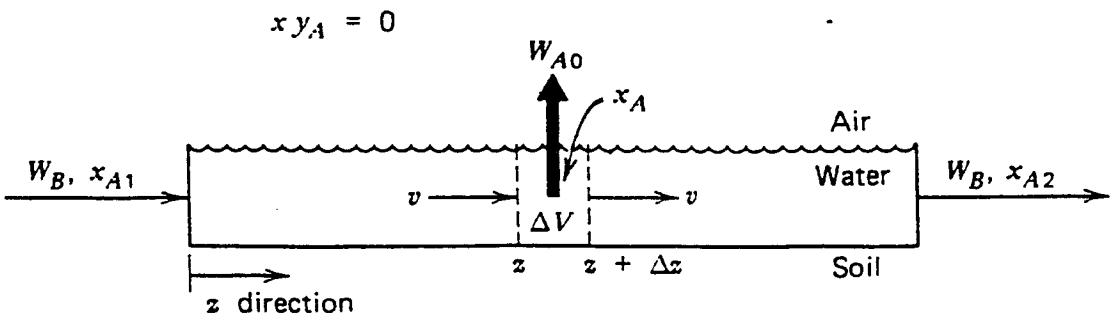
A = Area = $(\Delta z)W$

a_v = Interfacial area per unit volume

$W_B = vh\omega c_2$

(b) Intergrate the derived equation in part a) Using the boundary condition values where z=0, at $X_A = X_{A1}$ and z=L at $X_A = X_{A2}$ to generate the equation given below.

$$X_{A2} = X_{A1} \exp [-^1k_{A2}\, a_v\, v / W_B]$$



plug flow basin.

4. (a) *Terbitkan persamaan bagi satu proses penjerapan didalam satu reaktor aliran plug (plug flow basin). Mulakan dengan imbangan jisim bagi bahan A. Rujuk rajah yang diberikan di bawah.*

Dimana:

h= kedalaman reaktor

ω=lebar reaktor

X_A = mole purata bahan A

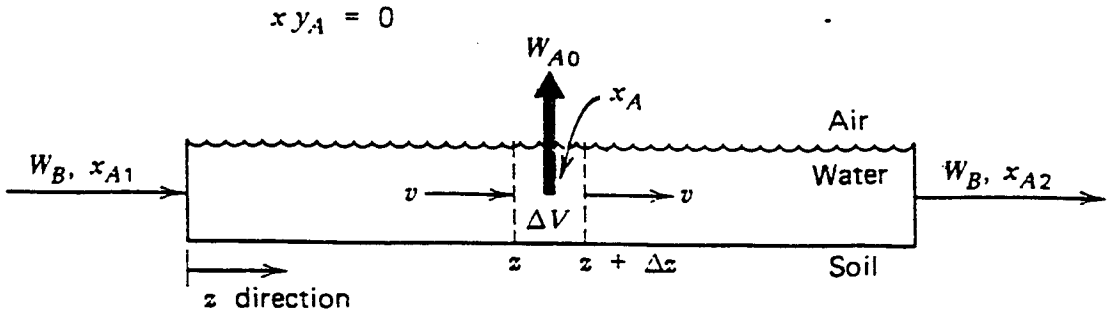
A = luas = $(\Delta z)W$

a_v = luas antaramuka per isipadu

$W_B = vh\omega c_2$

(b) *Kamirkan persamaan yang diterbitkan pada bahagian a) dengan menggunakan nilai tertentu z=0 pada $X_A = X_{A1}$ dan z=L pada $X_A = X_{A2}$ untuk menghasilkan persamaan seperti dibawah.*

$X_{A2} = X_{A1} \exp [-^1 k_{A2} a_v v / W_B]$



plug flow basin.

(100 markah)

5. Refer to the given figure 5.1 below. Prior to a second downstream sewage treatment plant (STP) coming on-line during which time septic system were used, a bacteriological study had been conducted for total E.Coli and the result of the survey is given in the table as follows:

X (kilometer	8	16	24	32
S(MPN/100ml)	46,500	16,700	9,000	2,800

MPN = most probable number bacteria

If the total coliform counts in both STP effluents are $3x10^6$ MPN/100ml without chlorine disinfection, what percent kills must be achieved by disinfection at the treatment plant to meet a beach total coliform standard of 2000MPN/100ml so that the beach can be used for bathing and beach activity.

Assume that equal reduction at both treatment plant and neglect STP flows in the flow balance.

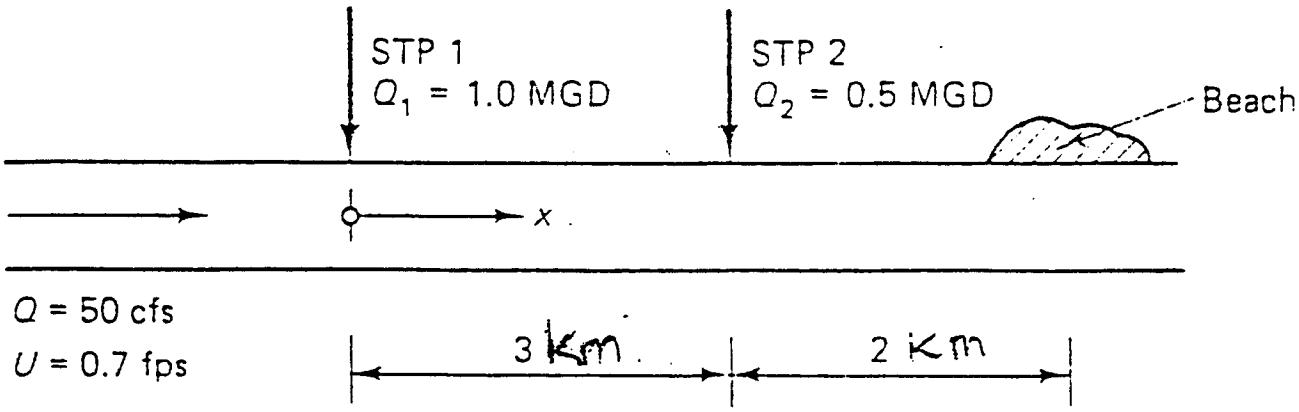
5. *Lihat rajah 5.1 yang diberikan di bawah. Sebelum titik punca kedua yang berunsur effluen domestik di discas kedalam sungai satu kajian bakteria menunjukkan bahawa jumlah E.coli di dalam sungai berkaitan ialah seperti di dalam jadual:*

X (kilometer	*8*	*16*	*24*	*32*
S(MPN/100ml)	*46,500*	*16,700*	*9,000*	*2,800*

MPN = most probable number bacteria

Jika jumlah purata bilangan E. coli pada kedua-dua loji pengolahan adalah $3x10^6$ MPN/100ml tanpa rawatan pengklorinan, berapakah peratus penurunan dicapai menerusi pengklorinan di loji rawatan supaya jumlah bilangan bakteria pada kawasan pantai dibahagian hilir tapak loji adalah 2000MPN/100ml dan selamat untuk berkelah dan mandi manda.

Anggapkan setiap rawatan klorin memberi kesan yang sama pada kedua dua loji rawatan air kumbahan.



STP = Sewage Treatment Plant
cfs = cubic feet per second
fps = feet per second
MGD = Million gallon per day

RAJAH 5.1

(100 markah)

6. The given equation below shows that the rate of decay of the organic material follows the first order.

$$S = S_o \exp(-Kt^*)$$

(a) Plot the figures for S versus t on a Cartesian coordinate.

(b) Plot the figures for ln S versus t on a semi- log.

(c) Show on the figure that indicates the waste input into a river or a canal with a velocity U using the above equation.

(d) What is meant by the parameter K in the above equation.

6. *Persamaan di bawah menunjukkan kadar bahan organik mereput mengikut tindak balas order pertama.*

$$S = S_o \exp(-Kt^*)$$

(a) Plotkan rajah parameter S lawan t pada graf kartesan.

(b) Plotkan rajah ln S lawan t pada kertas semi- log.

(c) Tunjukkan dengan rajah yang menggambarkan input suatu lepasan air sisa yang mengalir masuk ke dalam sungai atau alur pada halaju U berhubung dengan persamaan di atas.

(d) Apakah yang dimaksudkan dengan parameter K dalam persamaan di atas.

(100 markah)

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