UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2009/2010 Academic Session

April/May 2010

IEK 309 - CHEMODYNAMICS
[KIMODINAMIK]

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. On September 13, 1974, an electrical transformer fell during loading operations and caused a spill of 250 gal of 100% PCB (Aroclor 1242) into the Sg. Pahang in Kuantan, Pahang (PCB = polychlorinated bi-phenyl). The lower Pahang River is affected by tides up to 4 m and regularly flows at approximately 2 m/s. The spill site was a predominantly mud-silt bottom, with fresh water overlaying a saltwater wedge, and approximately 14 m deep and 150 m wide. The Dept. of Environment divers observed pools of free PCB (specific gravity 1.4) material on the bottom. There was evidence that the river current and tidal action had caused pockets of PCB to move about. Divers observed pools of PCB moving as much as 15 m with the tide from one day to the next.

   Using 4 in. hand-held suction dredgers, divers picked up pools of PCB from the bottom. The second-stage recovery utilized a special high solids dredger. On March 31, 1976, cleanup operations ceased. It is estimated that 210 to 240 gal of the original 250 gallons of PCB spilled were removed from the river bottom.

   (a) To investigate the possible fate of the unaccounted-for PCB (i.e., 10 to 40 gal), perform the following dissolution calculations:

      (i) Estimate the dissolution lifetime of the original 250 gal had no recovery operations been attempted.

      (ii) Estimate the maximum water concentration in the Sg Pahang (ppb).

      (iii) Estimate the quantity of material dissolved from September 13, 1974, through March 31, 1976 (gal).

   (50 marks)

   (b) In your opinion, where is the unrecovered PCB? List possible fates other than dissolution.

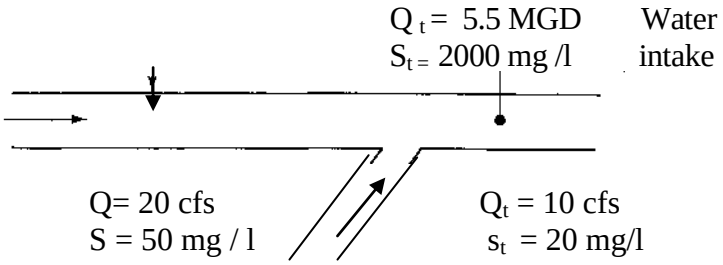
   Data needed for calculation:

   Solubility in water = 2.4E-4 mg/L,
   σ = 40 dynes/cm,
   P_A = 1.4,
   molecular weight 258,
   $D_{A2} \approx$ 0.8E-5 cm^2/s,
   and $^4K_{A2}$ = 7.0E-5 mol/cm2.s.

   (50 marks)

2. Upstream flow with a background level of chlorides, a conservative substance, of 50 mg/1 is supplemented by an industrial discharge of 5.5 MGD carrying 2000 mg/l chlorides and a downstream tributary of 10 cfs with background chlorides concentration. Assume downstream tributary chlorides concentration does not vary with flow.

   To maintain a desired chlorides concentration of 250 mg/1 at the water intake, determine: (a) the required industrial reduction or (b) the required increase in tributary flow *(Q_T)*.



(100 marks)

3. Approximately 1.5E6 pounds of chloroform were released from a barge that sank near Sg. Kinta, and the chemical began flowing down the Sg. Kinta toward the Straits of Malacca. Although state health officials did not push the panic button, noting that they did not anticipate too much trouble from the accident, the Marine Department warned downstream river communities to keep a close surveillance on their water supply systems, particularly if intakes were close to the river bottom (chloroform is heavier than water).

   Actually the river was at a low flow state, and there is reason to believe that the heavy chemical remained in place on the bottom near the spill site. Determine the:-

   (a) Maximum in-stream concentration. Using each shape dissolution model separately, calculate concentrations in ppb.

   (50 marks)

   (b) Minimum on-bottom lifetime. Using each shape dissolution model separately, calculate lifetimes (hr).

   (50 marks)

   Data: Bottom mass transfer coefficient, $^4k_{A2}$ = 5.00E-5 mol/cm^2.s; river flow, Q = 8000 m^3/s; ripple (sand wave) amplitude, Δ= 7.5 cm.

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

(100 marks)

5. (a) Discuss about oxygen equilibrium between air and water.

(25 marks)

(b) The time required for a stream to recover from a hypothetical state of no oxygen to some final degree of saturation gives an indication of speed of reaeration.

(i) Calculate the time required for a stream void of oxygen to reach 50% saturation. Find also the distance downstream and the oxygen concentration;

(ii) Calculate the time required to reach 90% saturation. Find also the distance and oxygen concentration.

Stream data: Average velocity v_w = 0.22 m/s; average depth h - 1.9 m, D(02)w = 1.8 x 10^{5} cm^2Is at 20° C; temperature of water = 29° C; at 29°C, p (02)w - 7-54 mg O2/L. The temperature coefficient for the system in the temperature range is 9 = 1.023.

$$k_{TI} = k_{T2}\theta^{(T1-T2)}$$

$$\rho_{(O2)w} = \rho^{*}_{(O2)w} - [\rho^{*}_{(O2)w} - \rho^{o}_{(O2)w}]\exp[-k_{(O2)w}\, t/h]$$

$$\Delta_{O2} = \rho^{*}_{(O2)w} - \rho_{(O2)w}$$

$$k_{(O2)w} = [D_{(O2)w} v_w / h]^{1/2}$$

(75 marks)

1. *Pada 13 September 1974, satu alat penjelmaan elektrik telah jatuh ketika operasi pemasangan dan menyebabkan tumpahan sebanyak 250 gal 100& PCB (Aroclor 1242) ke dalam Sg. Pahang di Kuantan, Pahang (PCB = polychlorinated bi-phenyl). Kawasan bawah Sg. Pahang dipengaruhi ombak sehingga 4 m dan aliran biasa dianggarkan 2 m/s. Kawasan tumpahan kebanyakannya merupakan dasar pasir selut, dengan air segar melapisi air masin, dan dianggarkan 14 m dalam dan 150 m lebar. Penyelam dari Jabatan Alam Sekitar menjumpai lopak PCB bebas (graviti spesifik 1.4) di dasar. Terdapat bukti bahawa tindakan arus dan ombak telah menyebabkan kantung PCB untuk bergerak. Penyelam mendapati lopak PCB tersebut bergerak paling banyak sejauh 15 m dengan ombak dari hari ke hari.*

   Dengan menggunakan alat penggali sedut kendalian tangan, penyelam menyedut lopak PCB dari dasar. Tahap kedua untuk pemulihan menggunakan penyedut pepejal khas. Pada 31 Mac 1976, kerja-kerja pembersihan dihentikan. Adalah dianggarkan bahawa 210 daripada 240 gal daripada jumlah asal 250 gal PCB yang tertumpah berjaya dipindahkan dari dasar sungai.

   (a) Untuk menyiasat segala kemungkinan berlaku pada PCB yang tidak diambil kira (i.e., 10 to 40 gal), laksanakan pengiraan untuk pembubaran berikut:

      (i) Anggarkan jangka masa pembubaran bagi asal 250 gal ketika tiada kerja-kerja pemulihan dijalankan.

      (ii) Anggarkan kepekatan maksimum air Sg. Pahang (ppb).

      (iii) Anggarkan kuantiti bahan terlarut dari 13 September 1974 hingga 31 Mac 1976 (gal).

   (50 markah)

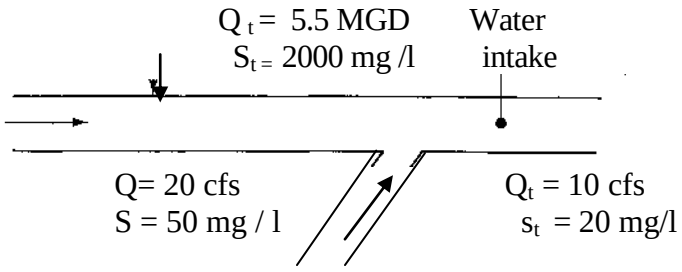
   (b) Pada pendapat anda, ke manakah PCB yang tidak ditemui? Senaraikan keadaan yang mungkin selain daripada pembubaran.

   Data diperlukan untuk pengiraan:
   Kelarutan dalam air = 2.4E-4 mg/L,
   σ = 40 dynes/cm,
   P_A = 1.4,
   Berat molekul 258,
   $D_{A2} \approx$ 0.8E-5 cm^2/s,
   dan $^4k_{A2}$ = 7.0E-5 $mol/cm^2.s$

   (50 markah)

2. *Pengaliran air ke hulu dengan tahap latar belakang klorida, sebatian yang konservatif, sebanyak 50mg/l digabungkan dengan pelepasan industri sebanyak 5.5 MGD dengan 2000 mg/l klorida dan anak sungai di hilir dengan 10cfs kepekatan latar belakang klorida. Andaikan kepekatan klorida di hilir sungai tidak bertukar dengan pengaliran air.*

   Untuk mengekalkan kepekatan klorida pada tahap 250 mg/l pada takat kemasukan air, tentukan (a) keperluan penurunan industri atau (b) peningkatan yang diperlukan dalam pengaliran anak sungai (Q).



(100 markah)

3. *Dianggarkan 1.5E6 paun klorofom telah dilepaskan dari tongkang yang karam berdekatan Sg. Perai, dan bahan kimia mula mengalir keluar dari Sg. Kinta ke Selat Melaka. Walaupun pihak berkuasa kesihatan negeri tidak mengeluarkan amaran berjaga-jaga, namun untuk mengelakkan sebarang perkara yang tidak diingini, Jabatan Laut telah mengeluarkan amaran kepada penduduk yang tinggal di hilir sungai untuk mengawasi sistem bekalan air, terutamanya pengambilan hampir dengan kawasan dasar sungai (klorofom lebih berat daripada air).*

   Sebenarnya, sungai tersebut berada dalam keadaan aliran perlahan, dan ada alasan bagi mempercayai bahawa bahan kimia berat kekal di kawasan dasar berdekatan kawasan tumpahan. Tentukan:

   (a) Kepekatan maksimum dalam sungai. Gunakan setiap bentuk model pembubaran secara berasingan, kirakan kepekatan dalam ppb.

   (50 markah)

   (b) Jangka hayat minimum atas dasar. Gunakan setiap bentuk model pembubaran secara berasingan, kirakan jangka hayat (jam).

   (50 markah)

   Data: koefisien pemindahan jisim dasar, $^4k_{A2}$ = 5.00E-5 mol/cm^2.s; aliran sungai, Q = 8000 m^3/s; riak (gelombang pasir) amplitud, Δ= 7.5 cm.

4. *Dengan bantuan gambarajah aliran, bincangkan jenis-jenis system pengolahan yang melibatkan pemprosesan air untuk air permukaan dan air bumi.*

(100 markah)

5. *(a) Bincangkan mengenai keseimbangan oksigen di antara udara dan air.*

(25 markah)

(b) Masa yang dikehendaki untuk suatu arus memulih dari keadaan hipotesis tanpa oksigen ke tahap ketepuan akhir tertentu memberikan suatu penunjuk laju pengudaraan semula.

(i) Hitungkan masa dikehendaki bagi suatu arus yang tanpa oksigen untuk mencapai 50% ketepuan. Carikan juga jarak hilir dan kepekatan oksigen;

(ii) Hitungkan masa dikehendaki untuk mencapai 50% ketepuan. Carikan juga jarak hilir dan kepekatan oksigen;

Data arus: halaju purata v_w = 0.22 m/s; kedalaman purata h = 1.9 m, $D_{(o2)}w$ = 1.8 x 10''^{5} cm^2/s pada 20°C; suhu air = 29°C; pada 29°C, P(02)w$^=$ V.54 mg O2/L. Koefisien suhu bagi system dalam julat suhu berkenaan ialah 0 = 1.023.*

$$k_{TI} = k_{T2}\theta^{(T1-T2)}$$

$$\rho_{(O2)w} = \rho^*_{(O2)w} - [\rho^*_{(O2)w} - \rho^o_{(O2)w}]\exp[-k_{(O2)w}t/h]$$

$$\Delta_{O2} = \rho^*_{(O2)w} - \rho_{(O2)w}$$

$$k_{(O2)w} = [D_{(O2)w}v_w/h]^{1/2}$$

(75 markah)

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