UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

## 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   FIVE   pages of printed material before you begin the examination.

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

**Instructions:**   Answer FIVE questions. You may answer the questions either in Bahasa Malaysia or in English.  Please answer Part A and Part B in separate answering booklets.

*[**Arahan:**  Jawab LIMA  soalan.  Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.  Sila jawab Bahagian A dan Bahagian B dalam buku jawapan yang berasingan.]*

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.]*

Answer any **FIVE** questions from Part A and B. Please answer Part A and Part B in separate answering booklets.

**Part A**

1.  (a)  Name **THREE** (3) physical and **THREE** (3) chemical water quality parameters of concern to environmental engineers and discuss their sources and impacts.

    (b)  Name and briefly describe **TWO** (2) major physical processes involved in self-purification of water courses.

    (100 marks)

2.  Water sample has the following compositions: calcium = 82 mg/L, magnesium = 33 mg/L, sodium = 14 mg/L, bicarbonate = 280 mg/L, sulfate = 82 mg/L and chloride = 36 mg/L.   Determine the carbonate hardness, non-carbonate hardness and total hardness, all in terms of mg/L $CaCO_3$. Construct an equivalent bar diagram for the cationic and anionic species of the water.

    Given the molecular weight of the species; $Ca^{2+}$ = 40g/mol; $Mg^{2+}$= 24.3g/mol; $Na^+$ = 23g/mol; $HCO_3^-$=61g/mol; $Cl^-$=35.5g/mol and $SO_4^{2-}$=96.1g/mol.

    (100 marks)

3.  At $20^oC$ the partial pressure (saturated) of chloroform, $CHCl_3$ is 18 mm Hg in a storage tank. Determine the equilibrium concentration of chloroform in water assuming the gas and liquid phases are ideal.

    Given 1 atm = 760 mm Hg, Henry's Law constant for chloroform at $20^oC$ is 170 atm/mol fraction, molecular weight of $CHCl_3$ = 119.4 g/mol, molecular weight of water = 18 g/mol and water density at $20^oC$ = 1000g/L.

    (100 marks)

**Part B**

4.  Describe the physical properties and purpose of a simple gravity settling tank. How can you modify it so that it can be converted into a sedimentation thickener? Show a complete diagram of a continuous thickener of a primary sludge removal tank in a water treatment plant.

(100 marks)

5.  A rotary drum filter with 30 percent submergence is to be used to filter concentrated aqueous slurry of $CaCO_3$ containing 14.7 lb of solid per cubic foot of water (236 kg/m$^3$). The pressure drop is to be 20 in (50.8cm) Hg. If the filter cake contains 50 percent moisture (wet basis), calculate the filter area required to filter 10 gal/min (37.8 L/min) of slurry when the filter cycle time is 5 min. Assume that the specific cake resistance and that the filter medium resistance $R_m$ is negligible. The temperature is 20°C.

(100 marks)

6.  A membrane process is being designed to recover solute A from a dilute solution where $c_1 = 2.0 \times 10^{-2}$ kg mol A/m$^3$ by dialysis through a membrane to a solution where $c_2 = 0.3 \times 10^{-2}$ kg mol A/m$^3$. The membrane thickness is $1.59 \times 10^{-5}$ m, the distribution coefficient $K' = 0.75$, $D_{AB} = 3.5 \times 10^{-11}$ m$^2$/s in the membrane, the mass-transfer coefficient in the dilute solution is $k_{c1} = 3.5 \times 10^{-5}$ m/s, and $k_{c2} = 2.1 \times 10^{-5}$ m/s.

    (a) Calculate the individual resistance, total resistance, and total percent resistance of the two films.

    (b) Calculate the flux at steady state and the total area in m$^2$ for a transfer of 0.01 kg mol solute/h.

    (c) Increasing the velocity of both liquid phases flowing past surface of the membrane will increase the mass-transfer coefficients, which are approximately proportional to $v^{0.6}$, where v is velocity. If the velocities are doubled, calculate the total percent resistance of the two films and the percent increase in flux.

(100 marks)

*Jawab sebarang LIMA soalan dari Bahagian A dan B. Sila jawab Bahagian A dan Bahagian B dalam buku jawapan yang berasingan.*

**Bahagian A**

1.  (a) Namakan **TIGA** (3) parameter fizikal dan **TIGA** (3) parameter kimia kualiti air yang menjadi pertimbangan jurutera persekitaran serta bincangkan sumber dan impak setiap parameter tersebut.

    (b) Namakan dan jelaskan secara ringkas **DUA** (2) proses fizikal utama yang terlibat dalam proses pemurnian-kendiri badan air.

    *(100 markah)*

2.  Sampel air memiliki komposisi seperti berikut: kalsium = 82 mg/L, magnesium = 33 mg/L, natrium = 14 mg/L, bikarbonat = 280 mg/L, sulfat = 82 mg/L dan klorida = 36 mg/L. Tentukan kekerasan karbonat, kekerasan bukan-karbonat dan kekerasan keseluruhan dalam sebutan mg/L $CaCO_3$. Bina gambarajah bar setara untuk spesies kationik dan anionik air tersebut.

    Diberi berat molekul spesies $Ca^{2+}$ = 40 g/mol; $Mg^{2+}$ = 24.3 g/mol; $Na^+$ = 23 g/mol; $HCO_3^-$ = 61 g/mol; $Cl^-$ =35.5 g/mol dan $SO_4^{2-}$ = 96.1 g/mol.

    *(100 markah)*

3.  Pada suhu $20^oC$ tekanan separa (tepu) kloroform, $CHCl_3$ adalah 18 mm Hg dalam tangki simpanan. Tentukan kepekatan keseimbangan kloroform dalam air dengan andaian fasa gas dan fasa cecair adalah unggul.

    Diberi 1 atm = 760 mm Hg, Pemalar Henry untuk kloroform pada suhu $20^oC$ adalah 170 atm/pecahan mol, berat molekul $CHCl_3$ = 119.4 g/mol, berat molekul air = 18 g/mol dan ketumpatan air pada suhu $20^oC$ = 1000g/L.

    *(100 markah)*

**Bahagian B**

4.  *Huraikan ciri-ciri fizikal dan tujuan asas suatu tangki pemendakan graviti. Bagaimanakah anda dapat mengubahsuaikannya agar ia ditukar sebagai pemekat endapan? Tunjukkan satu gambarajah "continuous thickener" bagi satu tangki pembuangan enapcemar di loji rawatan air.*

*(100 markah)*

5.  *Satu alat penuras berputar ditenggelamkan sebanyak 30 peratus dan digunakan untuk menuras buburan akues pekat $CaCO_3$ yang mengandungi 14.7 lb bahan pepejal pada setiap kaki persegi air (236 kg/m$^3$). Penurunan tekanan adalah 20 in.(50.8cm)Hg. Jika penuras kek mengandungi kelembapan 50 peratus (dasar lembap), kirakan luas penuras yang diperlukan untuk menuras 10 gal/min (37.8 L/min) buburan apabila masa kitaran penurasan adalah 5 minit. Anggap bahawa rintangan kek spesifik dan rintangan media penuras $R_m$ boleh diabaikan. Suhu adalah 20ºC.*

*(100 markah)*

6.  *Suatu proses membran direka untuk mendapatsemula bahan A daripada larutan cair di mana $c_1 = 2.0 \times 10^{-2}$ kg mol A/m$^3$ secara dialisis melalui membran ke satu larutan di mana $c_2 = 0.3 \times 10^{-2}$ kg mol A/m$^3$. Ketebalan membran adalah $1.59 \times 10^{-5}$ m, koefisien penyerakan K' = 0.75, $D_{AB} = 3.5 \times 10^{-11}$ m$^2$/s di dalam membran, koefisien pemindahan jisim dalam larutan cair adalah $k_{c1} = 3.5 \times 10^{-5}$ m/s, and $k_{c2} = 2.1 \times 10^{-5}$ m/s.*

    *(a)  Kirakan rintangan individu, rintangan keseluruhan dan peratusan rintangan keseluruhan kedua filem.*

    *(b)  Kirakan fluks pada keadaan mantap dan jumlah keluasan dalam unit m$^2$ untuk pemindahan 0.01kg mol cecair/jam.*

    *(c)  Apabila halaju kedua-dua fasa cecair yang mengalir melalui permukaan membran ditingkatkan, koefisien pemindahan jisim akan meningkat kira-kira $v^{0.6}$, di mana v adalah halaju. Jika halaju digandakan, kirakan peratusan jumlah rintangan kedua-dua filem dan peratus peningkatan dalam fluks.*

*(100 markah)*

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