UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2014/2015 Academic Session

June 2015

EKC 111 – Mass Balance
[Imbangan Jisim]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains NINE printed pages before you begin the examination.

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

Instruction: Answer **ALL** questions.

*[**Arahan:** Jawab **SEMUA** soalan.]*

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].

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Answer ALL questions.

1. The major components of a synthetic wastewater enters a lab scale treatment reactor are listed in Table Q.1. The reactor treats 8 liters of wastewater per day.

Table Q.1.

Component	mg/L
Glucose, $C_6H_{12}O_6$	467.5
Ammonium chloride, NH_4Cl	94.5
Dipotassium phosphate, K_2HPO_4	28.0

[a] Calculate the mole fraction of each components of the wastewater and the average molecular weight of the wastewater.

[8 marks]

[b] Calculate the ratio of nitrogen to phosphorus (N/P) in the wastewater enters the reactor.

[5 marks]

[c] In order to facilitate the treatment, the pH of the wastewater is adjusted by adding 4.31×10^{-4} lb_m of H_2SO_4 for each liter of the wastewater. If 35.0 wt% H_2SO_4 aqueous solution with a specific gravity of 1.2563 is used, calculate the required volume of H_2SO_4 aqueous solution that needs to be added to the reactor per day.

[6 marks]

[d] Estimate the percentage error that would have resulted if specific gravities of pure H_2SO_4 and water had been used for the calculation in [c] instead of the above given specific gravity of the H_2SO_4 aqueous solution. Given the specific gravity of pure H_2SO_4 is 1.8255.

[6 marks]

Jawab SEMUA soalan.

1. *Komponen utama air sisa sintetik yang memasuki reaktor rawatan berskala makmal adalah seperti di Jadual S.1. Reaktor tersebut merawat 8 liter air sisa sehari.*

Jadual S.1.

Komponen	**mg/L**
Glukosa, $C_6H_{12}O_6$	*467.5*
Ammonium klorida, NH_4Cl	*94.5*
Dipotassium fosfat, K_2HPO_4	*28.0*

[a] Kirakan pecahan mol setiap komponen air sisa tersebut dan berat molekul purata air sisa tersebut.

[8 markah]

[b] Kirakan nisbah nitrogen kepada fosforus (N/P) dalam air sisa yang memasuki reaktor tersebut.

[5 markah]

[c] Bagi memudahkan rawatan, pH air sisa tersebut diubah dengan menambah 4.31×10^{-4} lb_m H_2SO_4 bagi setiap liter air sisa. Sekiranya, larutan akueus H_2SO_4 35.0 %berat dengan graviti tentu 1.2563 digunakan, kirakan isipadu larutan akueus H_2SO_4 tersebut yang perlu ditambah kepada reaktor setiap hari.

[6 markah]

[d] Anggarkan peratus ralat yang mungkin terjadi sekiranya graviti tentu H_2SO_4 tulen dan air digunakan dalam pengiraan di [c] dan bukannya graviti tentu larutan akueus H_2SO_4 seperti di [c]. Diberi graviti tentu H_2SO_4 tulen ialah 1.8255.

[6 markah]

2. [a] In a distillation process, reflux is a very important stream. Briefly explain what is meant by reflux and what is the purpose and advantage having reflux in any distillation column.

[4 marks]

[b] Figure Q.2.[b] shows separation of 10,000 kg/h of equal weightage feed (*F*) of benzene and toluene mixture using a distillation column. The top product (*D*) recovered from the condenser contains 90% of benzene whereas the bottom product (*W*) contains 98% of toluene. The vapour stream (*V*) entering the condenser is 8,000 kg/h. A portion of the product from the condenser is returned to the column as reflux (*R*). Calculate the ratio of the amount refluxed to the bottom product.

[16 marks]

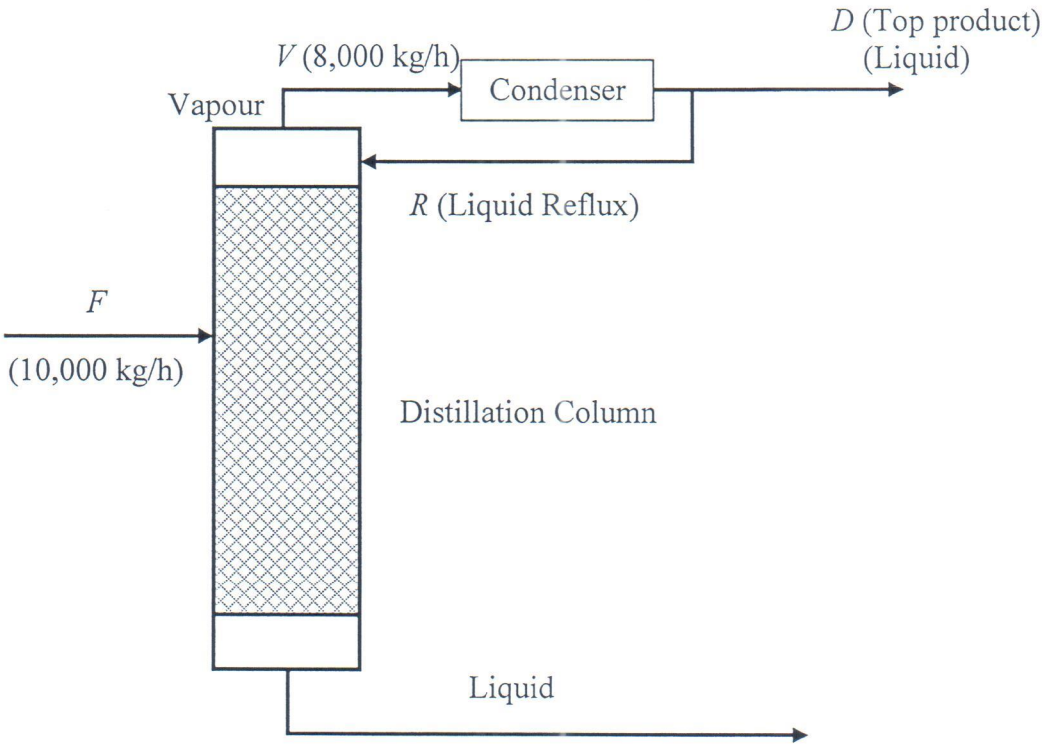


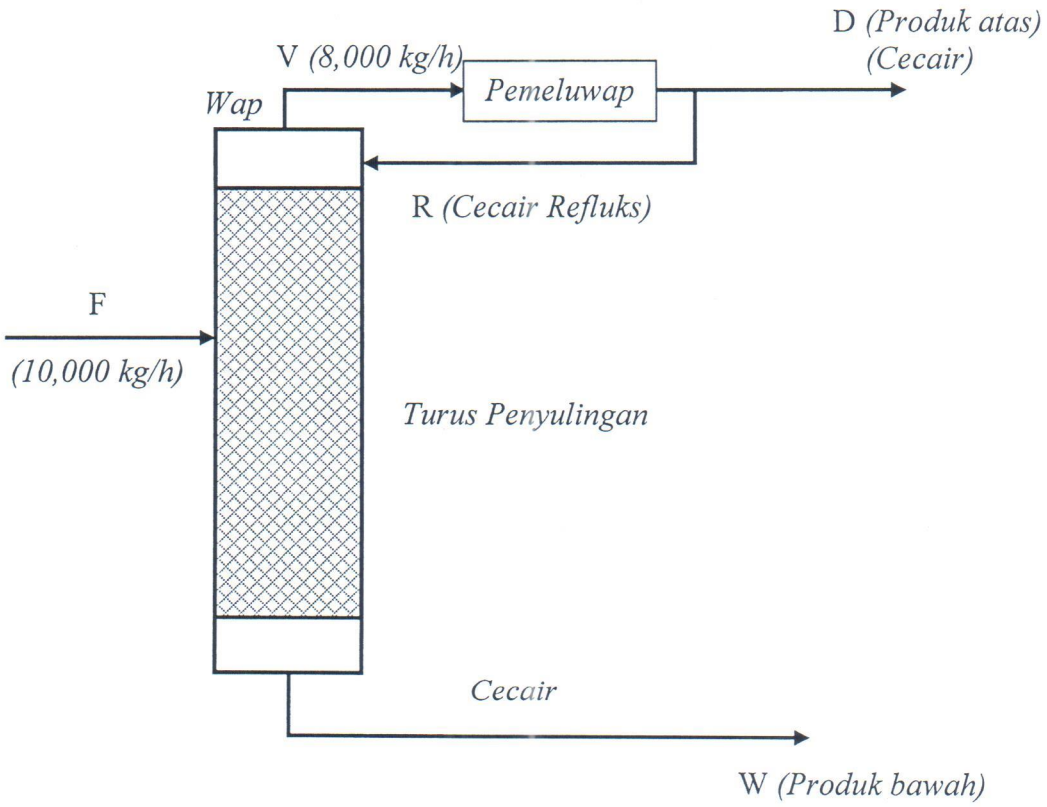
Figure Q.2.[b]

2. [a] *Bagi suatu proses penyulingan, refluks merupakan satu aliran yang penting. Huraikan secara ringkas apa yang dimaksudkan dengan refluks, tujuannya dan kepentingan adanya refluks bagi suatu turus penyulingan.*

[4 markah]

[b] *Rajah S.1.[b] menunjukkan pemisahan bagi 10,000 kg/jam suapan bagi campuran benzena dan toluena yang sama berat* (F) *menggunakan turus penyulingan. Produk atas* (D) *yang terhasil dari pemeluwap mengandungi 90% benzena manakala produk bawah* (W) *mengandungi 98% toluena. Aliran wap* (V) *memasuki pemeluwap pada kadar 8,000 kg/jam. Kirakan nisbah antara amaun yang direflukskan terhadap produk bawah.*

[16 markah]



Rajah S.2.[b].

3. CO_2 is separated from high temperature of gas mixture (CO_2, air and CH_4) using a tubular membrane as shown in Figure Q.3. The feed stream (*F*) enters the membrane and leaves at the end as the retentate stream (*R*). The gases being separated across the membrane leaves as the permeate stream (*P*). Both retentate and permeate streams are analysed and the data shows that 90% CO_2 and 20% O_2 diffuse across the membrane into the permeate stream. Calculate the gas composition in mol% and wt% in both retentate and permeate streams. The molecular weight of O_2, H_2, CO_2 and CH_4 are 32, 28, 44 and 16, respectively.

[10 marks]

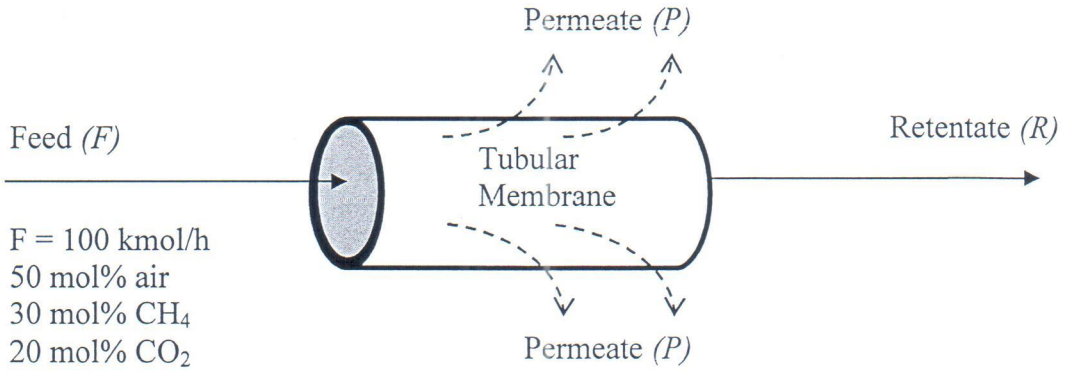


Figure Q.3.

4. [a] In any reaction process, briefly explain the following:

[i] Yield

[ii] Conversion

[iii] Selectivity

[6 marks]

[b] The following reactions take place in a continuous reactor at steady state.

$$C_2H_6 \rightarrow C_2H_4 + H_2$$
$$C_2H_6 + H_2 \rightarrow 2\,CH_4$$

The feed contains 85 mol% ethane (C_2H_6) and the balance is inerts (*I*). The fractional conversion of ethane is 0.501 and the fractional yield of ethylene (C_2H_4) is 0.471. Calculate the molar composition of the product gas (C_2H_6, C_2H_4, CH_4, H_2 & inerts *I*) and the selectivity of ethylene to methane production.

[14 marks]

5. [a] Find the value for the universal gas constant *R* at standard condition to match the following combination of units: For 1 g mol of ideal gas when the pressure is in bar, the volume is in cubic inches (in^3), and the temperature is in Rankine (°R).

[4 marks]

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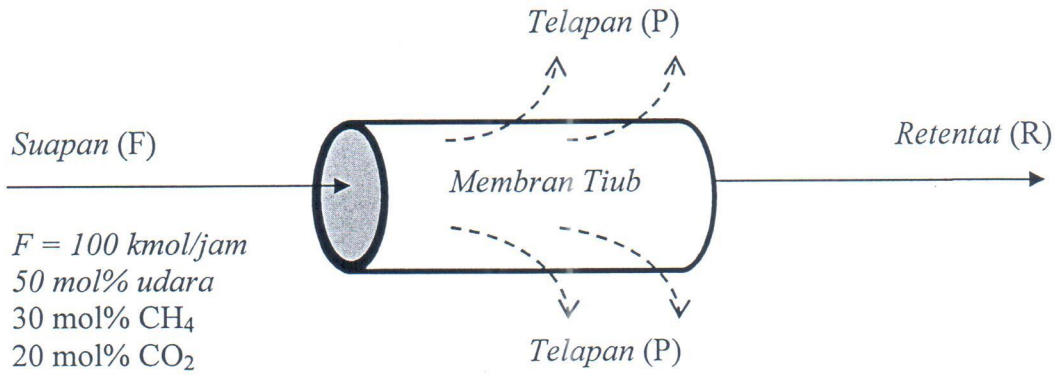
3. *CO_2 dipisahkan dari campuran gas (CO_2, udara dan CH_4) yang bersuhu tinggi dengan menggunakan membran tiub seperti yang ditunjukkan dalam Rajah S.3. Aliran suapan* (F) *memasuki membran dan keluar di bahagian hujung membran sebagai aliran retentat* (R). *Gas-gas dipisahkan merentasi membran dan keluar sebagai aliran telapan* (P). *Kedua-dua aliran retentat dan telapan dianalisa dan data yang diperolehi menunjukkan 90% CO_2 dan 20% O_2 meresap merentasi membran ke aliran telapan. Kirakan komposisi gas dalam peratus mol dan peratus berat bagi kedua-dua aliran retentat dan telapan. Jisim berat molekul bagi O_2, H_2, CO_2 dan CH_4 masing-masing adalah 32, 28, 44 dan 16.*

[10 markah]



Rajah S.3.

4. *[a] Bagi mana-mana proses tindak balas, terangkan secara ringkas perkara berikut:*

[i] Hasil

[ii] Penukaran

[iii] Kememilihan

[6 markah]

[b] Tindak balas-tindak balas berikut berlaku dalam sebuah reaktor berterusan pada keadaan mantap.

$$C_2H_6 \rightarrow C_2H_4 + H_2$$
$$C_2H_6 + H_2 \rightarrow 2\,CH_4$$

Suapan mengandungi 85 % mol etana (C_2H_6) dan bakinya ialah gas lengai (I). Pecahan penukaran etana ialah 0.501 dan pecahan hasil etilena (C_2H_4) ialah 0.471. Kirakan komposisi molar bagi gas produk (C_2H_6, C_2H_4, CH_4, H_2 & gas lengai I*) dan kememilihan etilena terhadap penghasilan metana.*

[14 markah]

5. *[a] Kirakan nilai pemalar gas* R *pada keadaan piawai untuk dipadankan dengan kombinasi unit berikut: bagi 1 g mol gas unggul, tekanan dalam bar, isipadu dalam inci padu (in^3), dan suhu dalam Rankine (R).*

[4 markah]

...8/-

[b] A gas stream contains benzene, toluene and *m*-xylene enters a separation unit, where it is separated and leaves the unit through 3 exit streams.

[i] The mass composition of the gas enters the separation unit is 50% benzene, 30% toluene and 20% *m*-xylene, at the rate of 483 m^3/h at 609 K and 26.8 atm. Estimate the mass flow rate of the gas enters the separation unit using the compressibility factor determined by the pseudo critical point method.

[13 marks]

[ii] The first exit stream of the separation unit is a vapor containing mass composition of 89.5% benzene, 8.4 % toluene and 2.1% *m*-xylene. The second exit stream is a liquid containing mass composition of 6.0% benzene, 9.0% toluene and 85.0% *m*-xylene. The third exit stream is liquid flowing at the rate of 9,800 kg/h consists of benzene, toluene and *m*-xylene. The mass ratio of the benzene to the *m*-xylene in the third stream is 3 to 2. Calculate the composition of the third exit stream.

[8 marks]

[b] Suatu aliran gas yang mengandungi benzena, toluena dan m-xilena memasuki unit pemisahan, di mana ia dipisahkan dan meninggalkan unit tersebut melalui 3 aliran keluar.

[i] Komposisi jisim gas yang memasuki unit pemisahan adalah benzena 50%, toluena 30% dan m-xilena 20%, kadar 483 m^3/jam pada 609 K dan 26.8 atm. Anggarkan kadar alir jisim gas yang memasuki unit pemisahan tersebut dengan menggunakan faktor kebolehmampatan yang ditentukan oleh kaedah titik kritikal pseudo.

[13 markah]

[ii] Aliran keluar pertama dari unit pemisahan tersebut ialah wap yang mengandungi komposisi jisim benzena 89.5%, toluena 8.4% dan m-xilena 2.1%. Aliran keluar kedua ialah cecair yang mengandungi komposisi jisim benzena 6.0%, toluena 9.0% dan m-xilena 85.0%. Aliran keluar ketiga ialah cecair yang mengalir pada kadar 9,800 kg/jam dan terdiri daripada benzena, toluena dan m-xilena. Nisbah jisim benzena kepada m-xilena dalam aliran keluar yang ketiga ialah 3 kepada 2. Kirakan komposisi aliran keluar ketiga.

[8 markah]

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