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UNIVERSITI SAINS MALAYSIA

Second Semester Examination  
2016/2017 Academic Session

June 2017

**EKC 111 – Mass Balance**  
***[Imbangan Jisim]***

Duration : 3 hours  
*[Masa : 3 jam]*

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

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

**Instruction:** Answer **ALL** (5) questions.

**Arahan:** Jawab **SEMUA** (5) 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].*

...2/-

Answer ALL questions.

1. For any reaction, define briefly the following terms:

- [a] Recycle [2 marks]
- [b] Bypass [2 marks]
- [c] Purging [2 marks]
- [d] Yield [2 marks]
- [e] Selectivity [2 marks]

2. Ethyl acetate ( $C_4H_8O_2$ ) is synthesized mainly via the esterification reaction of ethanol ( $C_2H_6O$ ) and acetic acid ( $C_2H_4O_2$ ). In an esterification reaction of ethanol with acetic acid the product stream consists of a mixture of 10.0 mole % ethanol, 15.0 mole % acetic acid and 75.0 mole % ethyl acetate. Given the specific gravity of ethanol is 0.789, acetic acid is 1.049 and ethyl acetate is 0.901 at 20 °C.

- [a] Calculate the mass fraction of each compound and the average molecular weight of the product stream mixture. [7 marks]
- [b] Determine the mass (in kg) of the product stream containing 2.50 m<sup>3</sup> of ethyl acetate. [6 marks]
- [c] The product stream of the esterification reaction passes through an extraction unit where the ethanol is extracted using water. The extraction process produces a mixture of ethanol and water. The mixture consists of 60.0 % water by mass.
  - [i] Calculate the volume of this mixture that contains 150 mol ethyl alcohol.
  - [ii] Assuming volume additivity, estimate the specific gravity of this mixture at 20 °C. [7 marks]
- [d] The heat capacity of ethanol can be expressed by,  
 $C_p$  (kJ/mol·°C) = 0.06134 + 15.72 × 10<sup>-5</sup> T(°C)  
Determine the expression for  $C_p$  in Btu/(lb mol)(°R) in terms of T (°R). [5 marks]

Jawab SEMUA soalan.

1. Bagi sesuatu tindakbalas, berikan definisi istilah-istilah berikut secara ringkas :

[a] Kitar semula

[2 markah]

[b] Pirau

[2 markah]

[c] Pembersihan

[2 markah]

[d] Hasil

[2 markah]

[e] Kememilihan

[2 markah]

2. Etil asetat ( $C_4H_8O_2$ ) disintesis terutamanya melalui tindak balas pengesteran etanol ( $C_2H_6O$ ) dan asid asetik ( $C_2H_4O_2$ ). Aliran produk suatu tindak balas pengesteran etanol dengan asid asetik terdiri daripada campuran 10.0 mol % etanol, 15.0 mol % asid asetik dan 75.0 mol % etil asetat. Diberi graviti tentu etanol adalah 0.789, asid asetik adalah 1.049 dan etil asetat adalah 0.901 pada 20 °C.

[a] Kirakan pecahan jisim setiap kompaun dan berat molekul purata campuran aliran produk.

[7 markah]

[b] Tentukan jisim (kg) aliran produk tersebut yang mengandungi 2.50 m<sup>3</sup> etil asetat.

[6 markah]

[c] Aliran hasil tindak balas pengesteran tersebut melalui suatu unit pengekstrakan di mana etanol diekstrak dengan menggunakan air. Proses pengekstrakan tersebut menghasilkan campuran etanol dan air. 60.0% jisim campuran tersebut terdiri daripada air.

[i] Kirakan isipadu campuran tersebut yang mengandungi 150 mol etil alkohol.

[ii] Dengan andaian kebolehtambahan isipadu, anggarkan graviti tentu campuran tersebut pada 20 °C.

[7 markah]

[d] Muatan haba etanol boleh dianggarkan dengan ungkapan,

$$C_p \text{ (kJ/mol}\cdot^\circ\text{C)} = 0.06134 + 15.72 \times 10^{-5} T(^{\circ}\text{C)}$$

Tentukan ungkapan tersebut bagi  $C_p$  dalam  $\text{Btu}/(\text{lb mol})(^{\circ}\text{R})$  dan  $T$  dalam ( $^{\circ}\text{R}$ ).

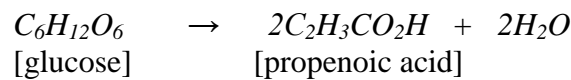
[5 markah]

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3. Two separate flasks, both contain mixture of methanol-water with different compositions. The first flasks contains 40 wt% methanol and the second flasks contains 70 wt% methanol. If 200 g mixture from the first flasks is combined with 150g mixture from the second flasks, what are the mass and composition of the final mixture.

[15 marks]

4. The yeast *Sacchaaromyes cerevisiae* digests glucose to form ethanol and propenoic acid in an aerobic fermentation of grain process. The overall reactions are as follows:



In a batch process, a tank is fed with 2000 kg of a 12% glucose/water solution and 88 kg of  $CO_2$ . At the end of the fermentation process, there are 208 kg of  $CO_2$  together with 90 kg of unreacted glucose.

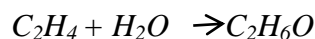
- [a] Calculate the weight, their respective weight% and mol% of all the components available in the tank at the end of the process.

[20 marks]

- [b] Calculate the selectivity of the ethanol.

[5 marks]

5. Ethanol ( $C_2H_6O$ ) is manufactured by reacting ethene ( $C_2H_4$ ) with steam using phosphoric acid as catalyst. A gaseous mixture consisting of 50 mol % ethene and 50 mol % steam is fed into a 500 L catalytic reactor at 300 °C and 65 atm abs. The formation of ethanol occurs according to;



At the end of the reaction it was noted that the total pressure in the reactor had dropped to 60 atm abs. Assume all reactants and product are in the gaseous state, the reactor and its contents were at the same temperature when the two pressures were measured.

- [a] Calculate the percentage of completion of the reaction at that time the pressure dropped to 60 atm abs assuming the gaseous mixture behaves ideally.

[5 marks]

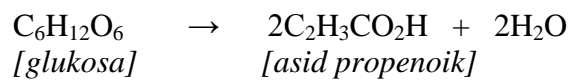
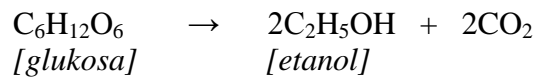
- [b] Calculate the total number of mol and mass of the gaseous mixture in the reactor at the end of the reaction assuming the gaseous mixture behaves ideally.

[8 marks]

3. Dua kelalang berasingan, kedua-duanya mengandungi campuran metanol-air dengan komposisi yang berbeza. Kelalang pertama mengandungi 40 %berat metanol dan kelalang kedua mengandungi 70 %berat metanol. Jika 200g campuran dari kelalang pertama digabungkan dengan 150g campuran dari kelalang kedua, apakah jisim dan komposisi campuran akhir.

[15 markah]

4. Yis *Saccharomyces cerevisiae* menghuraikan glukosa untuk membentuk etanol dan asid propenoik dalam satu proses penapaian aerobik bijirin. Tindak balas keseluruhan adalah seperti berikut :



Dalam proses kelompok, suatu tangki disuapkan dengan 2000 kg larutan 12% glukosa/air dan 88 kg CO<sub>2</sub>. Pada akhir proses penapaian, terdapat 208 kg CO<sub>2</sub> bersama-sama dengan 90 kg glukosa yang tidak bertindakbalas.

- [a] Bagi kesemua komponen yang terdapat dalam tangki pada akhir proses, kirakan berat, %berat dan %mol masing-masing.

[20 markah]

- [b] Kirakan kememilihan etanol.

[5 markah]

5. Ethanol (C<sub>2</sub>H<sub>6</sub>O) dihasilkan melalui tindak balas di antara etena (C<sub>2</sub>H<sub>4</sub>) dan stim dengan menggunakan asid fosforik sebagai pemangkin. Suatu campuran gas yang terdiri daripada 50% mol etena dan 50% mol stim dimasukkan ke dalam 500 L reaktor bermangkin pada 300 °C dan 65 atm abs. Pembentukan etanol berlaku mengikut ;



Pada akhir tindak balas diperhatikan bahawa jumlah tekanan dalam reaktor telah menurun kepada 60 atm abs. Anggap kesemua bahan tindak balas dan produk berada dalam keadaan gas, reaktor dan kandungannya berada pada suhu yang sama apabila kedua-dua tekanan tersebut diukur.

- [a] Kirakan peratus penyempurnaan tindak balas tersebut ketika tekanan menurun kepada 60 atm abs dengan menganggap campuran gas tersebut berkelakuan unggul.

[5 markah]

- [b] Kirakan jumlah bilangan mol dan jisim campuran gas di dalam reaktor pada akhir tindak balas dengan andaian campuran gas tersebut berkelakuan unggul.

[8 markah]

- [c] After the completion of the reaction an alarm was triggered due to a drop in the reactor pressure. An immediate inspection showed that the reactor pressure dropped to 50 atm abs, indicating a leak. Calculate the number of mol of  $C_2H_6O$  leaked at the time the leak is discovered using the compressibility chart assuming the gaseous mixture is compressible and behaving non-ideally.

*[12 marks]*

- [c] *Selepas tindak balas tamat penggera tercetus akibat penurunan tekanan reaktor. Pemeriksaan menunjukkan bahawa tekanan reaktor telah menurun kepada 50 atm abs, menandakan kebocoran. Kirakan bilangan mol  $C_2H_6O$  yang telah terlepas ketika kebocoran tersebut dikenalpasti dengan menggunakan carta kebolehmpatan. Anggap campuran gas tersebut boleh dimampat dan berkelakuan tidak unggul.*

[12 markah]