UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

IEK 101 – Penghitungan Proses Kimia
[Chemical Process Calculations]

Masa: 3 jam
Duration: 3 hours

Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA BELAS (13) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.

Jawab **LIMA (5)** daripada enam soalan. Nyatakan semua andaian anda. Semua soalan boleh dijawab sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.

[Please check that this examination paper consists of THIRTEEN (13) pages of printed material before you begin the examination.]

*[Answer **FIVE (5)** out of six questions. State all your assumptions. All questions can be answered either in Bahasa Malaysia or English.]*

1. (a) Dalam periuk yang manakah sejumlah isipadu air akan mendidih pada suhu yang lebih tinggi: periuk yang tinggi dan sempit atau periuk yang pendek dan lebar? Terangkan secara ringkas.

(4 markah)

(b) Penuhkan Jadual 1 bagi air. Sila lukis semua jadual ini dalam skrip jawapan anda.

Jadual 1

Suhu(°C)	Tekanan (kPa)	h (kJ/kg)	x (kualiti)	Penerangan Fasa
600		3570		
	600		0.4	
200	1750			

(8 markah)

(c) Satu bekas tegar $0.4m^3$ pada mulanya mengandungi campuran cecair wap tepu H_2O pada 100°C. Air dipanaskan sehingga mencapai keadaan kritikal. Tentukan jisim cecair H_2O dan isipadu yang diambil oleh cecair H_2O pada keadaan mula. Lakarkan proses merujuk kepada garisan tepu.

(8 markah)

2. (a) Satu campuran gas yang terdiri daripada 15 lb N_2 dan 20 lb H_2 berada pada tekanan 50 psig dan suhu 60°F. Tentukan yang berikut dengan menganggap bahawa campuran ini adalah unggul.

(a) Tekanan separa bagi setiap komponen
(b) Isipadu spesifik bagi campuran
(c) Ketumpatan campuran

(10 markah)

(b) Satu campuran gas terdiri daripada komposisi berikut (dalam peratusan mol)

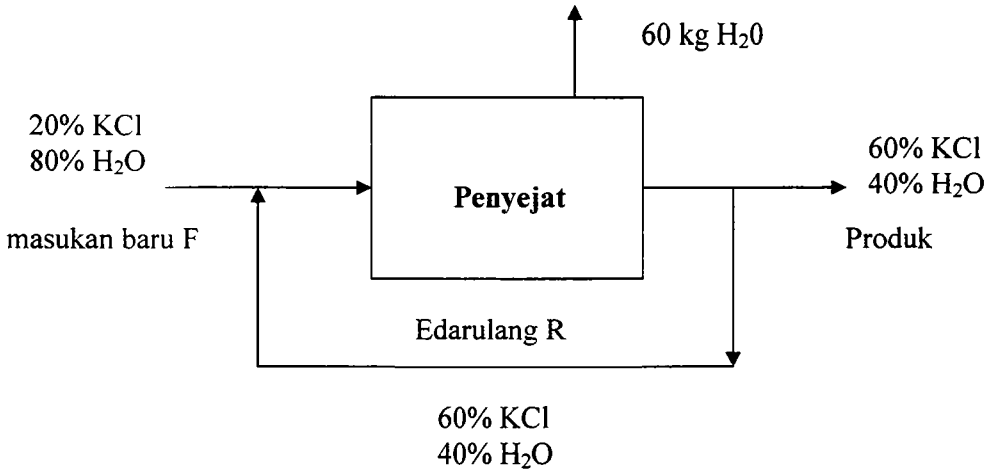
C_2H_4	57
Ar	40
He	3

pada tekanan 120 atm dan 25°C. Bandingkan isipadu eksperimen 0.14L/gmol dengan isipadu yang diperolehi menggunakan kaedah Kay.

(10 markah)

3. (a) Lihat Rajah 1. Hitung kg R/100 kg masukan baru.

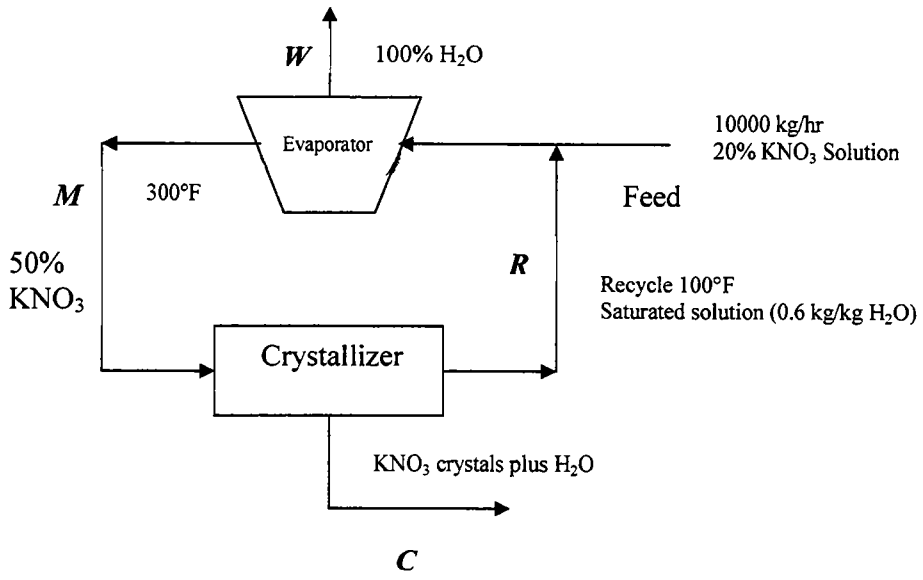
(4 markah)



Rajah 1

(b) Teliti Rajah 2. Apakah kuantiti aliran edarulang dalam kg/jam? Dalam aliran C, komposisi ialah 4% air dan 96% KNO_3.

(8 markah)



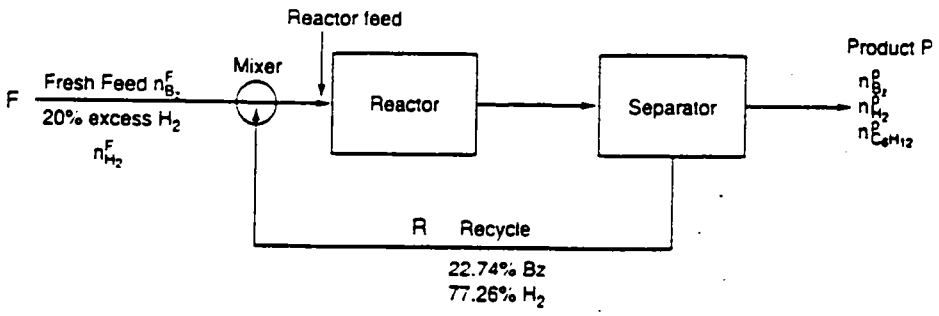
Rajah 2

(c) Cycloheksana (C_6H_{12}) boleh dibentuk dengan tindakbalas benzena (bz) (C_6H_6) dengan hidrogen menurut tindakbalas berikut:

$$C_6H_6 + 3H_2 \rightarrow C_6H_{12}$$

Bagi proses yang ditunjukkan di Rajah 3, tentukan nisbah aliran edarulang kepada aliran masukan baru jika pertukaran keseluruhan benzena ialah 95% dan pertukaran laluan tunggal ialah 20%. Anggapkan 20% hidrogen berlebihan digunakan dalam masukan baru dan komposisi aliran edarulang ialah 22.74 mol % benzena dan 77.26% hidrogen.

(8 markah)



Rajah 3

4. (a) Air dipanaskan di dalam periuk bertutup di atas dapur dengan dikacau dengan roda-pengayuh. Semasa proses, 30kJ haba dipindahkan kepada air dan 5kJ haba hilang ke udara sekeliling. Kerja yang dijalankan ialah sebanyak 500J. Tentukan tenaga akhir sistem jika tenaga dalaman permulaan ialah 10kJ.

(4 markah)

(b) Tentukan haba pembentukan standard bagi FeO (s) diberi nilai-nilai haba tindakbalas pada 25°C and 1 atm bagi tindakbalas-tindakbalas berikut:

$$2Fe(s) + \frac{3}{2} O_2 (g) \rightarrow Fe_2O_3 (s) \qquad : -822{,}200 \text{ J}$$

$$2FeO (s) + ½ O_2(g) \rightarrow Fe_2O_3(s) \qquad : -284{,}100 \text{ J}$$

Bandingkan nilai ini dengan nilai yang diperolehi menggunakan buku data.

(6 markah)

(c) Kirakan haba tindakbalas kimia bagi tindakbalas berikut:

(i) $CO_2 (g) + H_2 (g) \rightarrow CO (g) + H_2O (l)$

(ii) $Na_2SO_4 (s) + C (s) \rightarrow Na_2SO_3 (s) + CO (g)$

(iii) $NaCl(s) + H_2SO_4 (l) \rightarrow NaHSO_4 (s) + HCl (g)$

(iv) $SO_2 (g) + ½ O_2 (g) + H_2O (l) \rightarrow H_2SO_4(l)$

(10 markah)

5. (a) Fosgene boleh dihasilkan dengan tindakbalas bermangkin di antara CO dan gas klorin dengan kehadiran pemangkin karbon. Tindakbalas kimia ialah :

$$CO + Cl_2 \rightarrow CO\,Cl_2$$

Katakan anda telah menyukat produk tindakbalas di dalam reaktor dan mendapati ia mengandungi 3 kg klorin, 10 kg fosgene dan 7 kg CO. Hitung yang berikut:

(i) peratus reaktan berlebihan yang digunakan

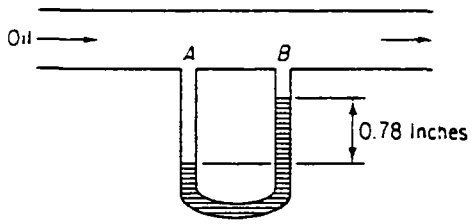
(ii) peratus pertukaran reaktan penghad

(iii) kg mol fosgene yang terbentuk per kg mol jumlah reaktan yang dimasukkan dalam reaktor

(10 markah)

(b) Teliti Rajah 4. Minyak (ketumpatan = 0.91g/cm^3) mengalir di dalam paip dan kadar aliran diukur menggunakan manometer merkuri (ketumpatan=13.546 g/cm3). Jika perbezaan dalam ketinggian kedua jalur manometer ialah 0.78 inci, apakah perbezaan tekanan di antara titik A dan B dalam mm Hg? Pada titik yang manakah, A atau B, tekanan adalah lebih tinggi? Suhu adalah pada 60F.

(10 markah)



Rajah 4

6. Asid Nitrik (HNO_3) yang digunakan di industri bagi pelbagai tindakbalas, boleh dihasilkan dengan tindakbalas ammonia (NH_3) dengan udara melalui tindakbalas keseluruhan berikut:

$$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$$

Produk daripada reaktor tersebut mengandungi komposisi berikut (dasar tanpa kandungan air)

0.8% NH_3
9.5% HNO_3
3.8% O_2
85.9% N_2

Tentukan peratus pertukaran NH_3 and peratus lebihan udara yang digunakan.

(20 markah)

1. (a) *In what kind of pot will a given volume of water boil at a higher temperature: a tall and narrow pot or a short and wide one? Briefly explain.*

(4 marks)

(b) *Complete Table 1 for water . Please redraw this table in your answer script.*

Table 1

Temp (°C)	Pressure (kPa)	h (kJ/kg)	x (quality)	Phase Description
600		3570		
	600		0.4	
200	1750			

(8 marks)

(c) *A rigid container with a volume of 0.4 m^3 initially contains saturated liquid-vapor mixture of water at 100C. The water is now heated until it reaches the critical state. Determine the mass of the liquid water and the volume occupied by the liquid at the initial state. Sketch this process in relation to the saturated curves.*

(8 marks)

2. (a) *A gas mixture consisting of 15 lbs N_2 and 20lbs H_2 is at a pressure of 50 psig and temperature of 60°F. Determine the following by assuming that the mixture is ideal:*

a) partial pressure of each component
b) specific volume of the mixture
c) density of the mixture

(10 marks)

(b) *A gaseous mixture has the following composition (in mol percent):*

C_2H_4	57
Ar	40
He	3

at 120 atm pressure and 25°C. Compare the experimental volume of 0.14L/g mol with that computed by Kay's method.

(10 marks)

3. a) *See Figure 1. Find the kg R/100 kg fresh feed.*

(4 marks)

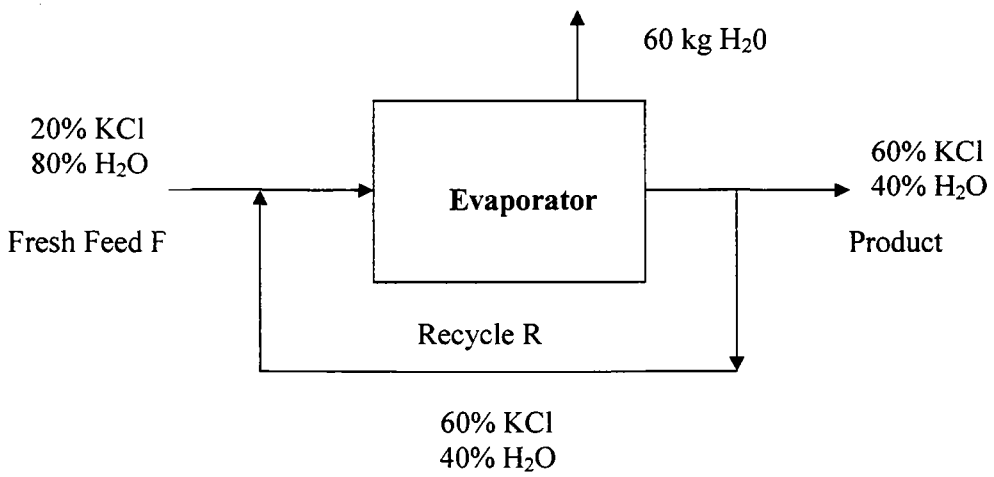


Figure 1

(b) Examine Figure 2. What is the quantity of the recycle stream in kg/hr? In stream C the composition is 4% water and 96% KNO_3

(8 marks)

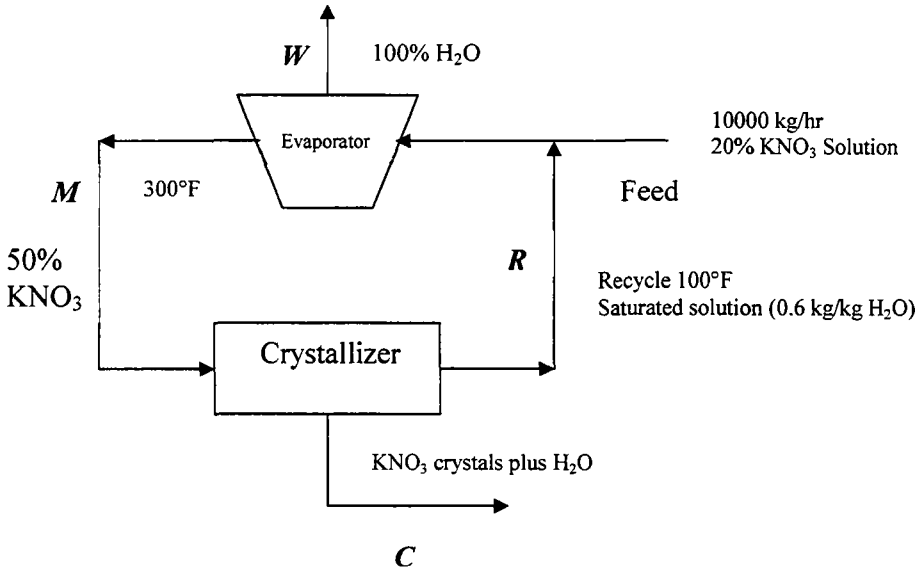


Figure 2

(c) *Cyclohexane (C_6H_{12}) can be made by the reaction of Benzene (Bz) with hydrogen according to the following reaction:*

$$C_6H_6 + 3H_2 \rightarrow C_6H_{12}$$

For the process shown in Figure 3, determine the ratio of the recycle stream to the fresh feed stream if the overall conversion of benzene is 95%, and the single pass conversion is 20%. Assume that 20% excess hydrogen is used in the fresh feed, and that the composition of the recycle stream is 22.74 mol % benzene and 77.26 mol % hydrogen.

(8 marks)

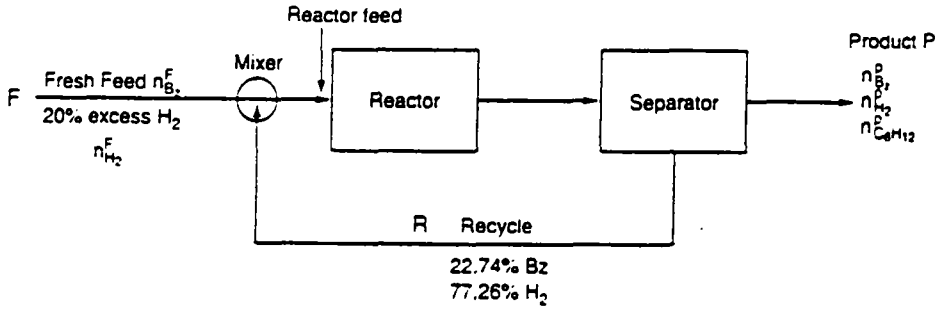


Figure 3

4. (a) *Water is heated in a closed pot on top of a stove while being stirred by a paddle wheel. During the process, 30kJ of heat is transferred to the water, and 5 kJ of heat is lost to the surrounding air. The work done amounts to 500J. Determine the final energy of the system if its initial internal energy was 10 kJ*

(4 marks)

(b) *Determine the standard heat of formation for FeO (s) given the following values for the heats of reaction at 25°C and 1 atm for the following reactions:*

$$2Fe(s) + \frac{3}{2} O_2(g) \rightarrow Fe_2O_3(s) \qquad : -822{,}200\ J$$

$$2FeO(s) + \tfrac{1}{2} O_2(g) \rightarrow Fe_2O_3(s) \qquad : -284{,}100\ J$$

Compare it with the value obtained in the data book.

(6 marks)

(c) *Calculate the standard heat of reaction for the following reactions:*

(i) $CO_2\ (g) + H_2\ (g) \rightarrow CO\ (g) + H_2O\ (l)$

(ii) $Na_2SO_4\ (s) + C\ (s) \rightarrow Na_2SO_3\ (s) + CO\ (g)$

(iii) $NaCl(s) + H_2SO_4\ (l) \rightarrow NaHSO_4\ (s) + HCl\ (g)$

(iv) $SO_2\ (g) + \frac{1}{2}\ O_2\ (g) + H_2O\ (l) \rightarrow H_2SO_4(l)$

(10 marks)

5. (a) *Phosgene can be made by the catalytic reaction between CO and chlorine gas in the presence of a carbon catalyst. The chemical reaction is:*

$$CO + Cl_2 \rightarrow CO\ Cl_2$$

Suppose that you have measured the reaction products in a given reactor and found that they contained 3 kg of chlorine, 10 kg of phosgene and 7 kg of CO. Calculate the following:

(i) *the percent excess reactant used*
(ii) *the percentage conversion of the limiting reactant*
(iii) *the kg mol of phosgene formed per kg mol of total reactants fed to the reactor*

(10 marks)

(b) *Examine Figure 4. Oil (density = 0.91 g/cm3) flows in a pipe, and the flow rate is measured via a mercury (density= 13.546 g/cm3) manometer. If the difference in height of the two legs of the manometers 0.78 in., what is the corresponding pressure difference between points A and B in mm Hg? At which point, A or B, is the pressure higher? The temperature is 60°F.*

(10 marks)

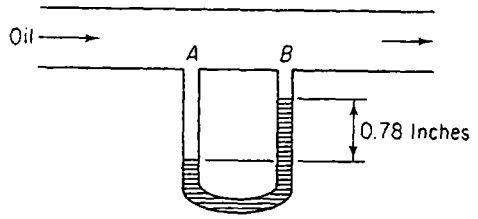


Figure 4

6. *Nitric acid (HNO_3) that is used industrially for a variety of reactions can be produced by the reaction of ammonia (NH_3) with air by the following overall reaction:*

$$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$$

The product gas from such a reactor has the following composition (on a water free basis):

0.8% NH_3
9.5% HNO_3
3.8% O_2
85.9% N_2

Determine the percent conversion of NH_3 and the percent excess air used

(20 marks)

- oooOooo -