

UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2005/2006

April/May 2006

IEK 101 – Chemical Process Calculations
[Penghitungan Proses Kimia]

Duration: 3 hours
[Masa: 3 jam]

Please check that the examination paper consists of ELEVEN (11) pages of printed material before you begin this examination.

Answer **THREE** questions. Answer all questions in Part A using the OMR form, and answer TWO out of **THREE** questions in Part B in the answer book. Write down all your basis and assumptions in Part B.

This examination paper is not allowed to be taken out from the examination hall.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS (11) mukasurat yang bercetak sebelum anda memulakan peperiksaan ini.]

*[Jawab **TIGA** soalan. Jawab semua soalan dalam Bahagian A menggunakan borang OMR dan jawab **DUA** daripada **TIGA** soalan Bahagian B dalam buku jawapan. Tulis semua dasar dan andaian anda bagi Bahagian B.]*

[Kertas soalan ini tidak dibenarkan dibawa keluar daripada Dewan Peperiksaan.]

...2/-

PART A

1. A tank contains 300 kg of a mixture of gases. The composition of the tank is as follows: 10.0% H₂, 40.0% CH₄, 30.0% CO and 20.0% CO₂. What is the average molecular weight of the gas?
- A. 23.8 kg/kgmol
 - B. 7140 kg/kgmol
 - C. 71.40 kg/kgmol
 - D. 238 kg/kgmol
 - E. none of the above

Question 2 - 5 refers to the following statement:

2 kg of H₂O is contained in a cylinder-piston device which is initially at 1.10 MPa and 300°C. It is then cooled at constant pressure until half of its mass condenses.

2. What is the initial phase of the H₂O?
- A. Compressed liquid
 - B. Saturated water
 - C. Saturated liquid-vapor mixture
 - D. Saturated vapour
 - E. Superheated vapour
3. What is its initial enthalpy?
- A. 7871.7 kJ
 - B. 3048.5 kJ
 - C. 6097 kJ
 - D. 5582.4 kJ
 - E. None of the above
4. What is the change in volume during the process?
- A. 0.0893 m³
 - B. 0.1798 m³
 - C. 0.1116 m³
 - D. 0.2926 m³
 - E. None of the above

5. What is its final condition and final temperature ?
- Saturated liquid-vapour mixture, 300°C
 - Saturated water, 184.09°C
 - Saturated liquid-vapour mixture, 184.09°C
 - Saturated vapour, 184.09°C
 - None of the above
6. Examine Figure 1. The barometer reads 730 mmHg. Calculate the pressure in the tank in psia.

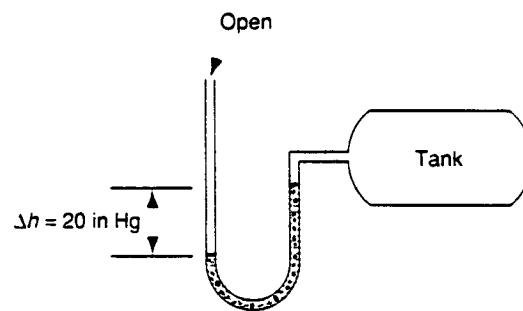


Figure 1

- 23.95 psia
 - 4.29 psia
 - 4.5 psia
 - 4.29 psia
 - none of the above
7. Oil (Sp. Gravity = 0.8) is flowing through a 6 inch diameter pipe with a velocity of 56.7 ft/s. What is the flow rate of the oil in m^3/s ?
- $0.32 \text{ m}^3/\text{s}$
 - $1.26 \text{ m}^3/\text{s}$
 - $0.24 \text{ m}^3/\text{s}$
 - $0.4 \text{ m}^3/\text{s}$
 - none of the above

8. The specific gravity of a solution KOH at 15°C is 1.0824 and contains it 0.813 lb KOH per gallon of solution. What is the mass fraction of KOH in the solution?
- A. 0.012
 - B. 0.91
 - C. 0.99
 - D. 0.09
 - E. none of the above
9. If dibromopentane (DBP) has a specific gravity of 1.57, what is its density in lb_m/ft^3 ?
- A. $1570 \text{ lb}_m/\text{ft}^3$
 - B. $97.97 \text{ lb}_m/\text{ft}^3$
 - C. $15.7 \text{ lb}_m/\text{ft}^3$
 - D. $3.45 \text{ lb}_m/\text{ft}^3$
 - E. none of the above
10. What is the density of O_2 at 100°C and 740 mm Hg in lb/ft^3 ?
- A. 0.076
 - B. 0.76
 - C. 1.22
 - D. 0.122
 - E. none of the above

(50 marks)

...5/-

PART B. Answer any TWO out of 3 questions.

1. (a) Superheated vapor (H_2O) at 250 kPa and 500°C is allowed to cool at constant volume until the temperature reduces to 95°C . At its final condition, determine its:

- i. Pressure
- ii. Quality
- iii. Enthalpy
- iv. Sketch this process on a T-v diagram referring to saturation lines

(10 marks)

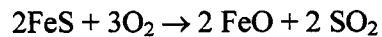
- (b) Determine the specific volume of superheated vapor (H_2O) at 10 MPa and 400°C using:

- i. ideal gas equation
- ii. steam table
- iii. generalized compressibility charts

Which method gives the most accurate value?

(15 marks)

2. (a) FeS can be roasted in O_2 to form FeO.



If the slag (solid product) contains 80% FeO and 20% FeS, and the exit gas is 100% SO_2 , determine the extent of reaction and the initial number of moles of FeS. Use 100 kg as the basis.

(10 marks)

- (b) Several streams are mixed as shown in Figure 2. Calculate the flows of each stream in kg/s.

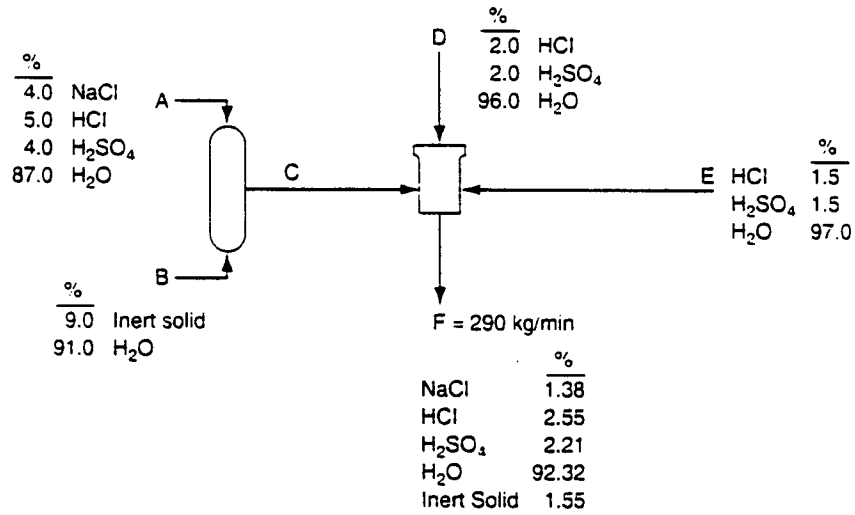


Figure 2

(15 marks)

3. (a) Steam enters a long horizontal pipe with the inlet diameter $D_1 = 12$ cm at 1 MPa and 250°C with a velocity of 2 m/s. The outlet condition is at 800 kPa and 200°C and the outlet diameter is $D_2 = 10$ cm. Determine:

- The mass flow rate of the steam
- The rate of heat transfer

(15 marks)

- (b) Calculate the heat of reaction at the standard reference state for the following reactions:

- $\text{Na}_2\text{SO}_4 (\text{s}) + \text{C} (\text{s}) \rightarrow \text{Na}_2\text{SO}_3 (\text{s}) + \text{CO} (\text{g})$
- $\text{NaCl} (\text{s}) + 2\text{SO}_2 + 2\text{H}_2\text{O} (\text{l}) + \text{O}_2 (\text{g}) \rightarrow 2\text{Na}_2\text{SO}_4 (\text{s}) + 4 \text{HCl} (\text{g})$
- $\text{NaCl} (\text{s}) + \text{H}_2\text{SO}_4 (\text{l}) \rightarrow \text{NaHSO}_4 (\text{s}) + \text{HCl} (\text{g})$
- $\text{C}_2\text{H}_2 (\text{g}) + \text{H}_2\text{O} (\text{l}) \rightarrow \text{CH}_3\text{CHO} (\text{l})$

(10 marks)

...7/-

BAHAGIAN A

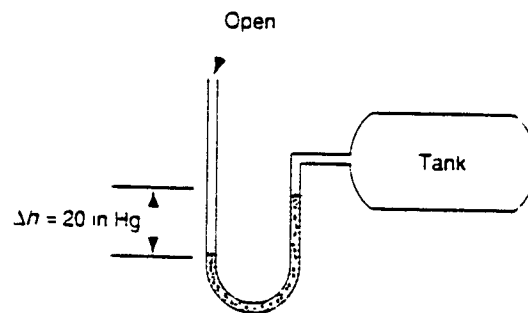
1. Satu tangki mengandungi 300 kg campuran gas. Komposisi tangki ialah 10.0% H₂, 40.0% CH₄, 30.0% CO and 20.0% CO₂. Apakah purata jisim molekul bagi campuran gas tersebut?
 - A. 23.8 kg/kgmol
 - B. 7140 kg/kgmol
 - C. 71.40 kg/kgmol
 - D. 238 kg/kgmol
 - E. Tiada di atas

Soalan 2-5 rujuk kepada kenyataan di bawah:

2 kg H₂O terkandung dalam alat silinder-piston yang pada mulanya pada 1.10 MPa dan 300°C. Ia kemudiannya disejukkan pada tekanan malar sehingga separuh daripada jisimnya terpeluwap.

2. Apakah fasa permulaan H₂O tersebut?
 - A. Cecair termampat
 - B. Cecair tepu
 - C. Campuran cecair-wap tepu
 - D. Wap tepu
 - E. Wap panas lampau
3. Apakah entalpi permulaan?
 - A. 7871.7 kJ
 - B. 3048.5 kJ
 - C. 6097 kJ
 - D. 5582.4 kJ
 - E. tiada di atas
4. Apakah perubahan isipadu semasa proses ini?
 - A. 0.0893 m³
 - B. 0.1798 m³
 - C. 0.1116 m³
 - D. 0.2926 m³
 - E. tiada di atas

5. Apakah keadaan dan suhu akhir H_2O ?
- Saturated liquid-vapour mixture, $300^\circ C$
 - Saturated water, $184.09^\circ C$
 - Saturated liquid-vapour mixture, $184.09^\circ C$
 - Saturated vapour, $184.09^\circ C$
 - Tiada di atas
6. Teliti Rajah 1. Bacaan barometer ialah 730 mmHg . Hitung tekanan dalam tangki dalam psia.



Rajah 1

- 23.95 psia
 - -4.29 psia
 - 4.5 psia
 - 4.29 psia
 - tiada di atas
7. Minyak (Gravity tentu = 0.8) mengalir melalui paip berdiameter 6 inci dengan kelajuan 56.7 ft/s . Apakah kadar aliran minyak tersebut dalam m^3/s ?
- $0.32 \text{ m}^3/\text{s}$
 - $1.26 \text{ m}^3/\text{s}$
 - $0.24 \text{ m}^3/\text{s}$
 - $0.4 \text{ m}^3/\text{s}$
 - tiada di atas

8. Graviti tentu satu larutan KOH pada 15°C ialah 1.0824 dan ia mengandungi 0.813 lb KOH per gelen larutan. Apakah pecahan jisim KOH dalam larutan?
- A. 0.012
 - B. 0.91
 - C. 0.99
 - D. 0.09
 - E. tiada di atas
9. Jika dibromopentana (DBP) mempunyai graviti tentu 1.57, apakah ketumpatannya dalam lb_m/ft^3 ?
- A. $1570 \text{ lb}_m/\text{ft}^3$
 - B. $97.97 \text{ lb}_m/\text{ft}^3$
 - C. $15.7 \text{ lb}_m/\text{ft}^3$
 - D. $3.45 \text{ lb}_m/\text{ft}^3$
 - E. tiada di atas
10. Apakah ketumpatan O_2 pada 100°C dan 740 mm Hg dalam lb/ft^3 ?
- A. 0.076
 - B. 0.76
 - C. 1.22
 - D. 0.122
 - E. tiada di atas

(50 markah)

...10/-

BAHAGIAN B. Jawab DUA daripada 3 soalan.

1. (a) Wap panas lampau H₂O pada 250kPa dan 500°C dibiarkan sejuk pada isipadu malar sehingga suhu menurun kepada 95°C. Pada keadaan akhir, tentukan:

- i. Tekanan
- ii. Kualiti
- iii. Entalpi
- iv. Lukis proses ini dalam gambarajah T-ν merujuk kepada garisan tepu

(10 markah)

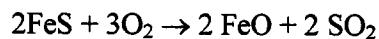
- (b) Tentukan isipadu spesifik bagi wap panas lampau (H₂O) pada 10 MPa dan 400°C menggunakan:

- i. Persamaan gas unggul
- ii. Jadual stim
- iii. Carta kebolehmampatan teritlak

Kaedah manakah akan memberi nilai yang paling jitu?

(15 markah)

2. (a) Fes boleh di bakar dalam O₂ untuk membentuk FeO.

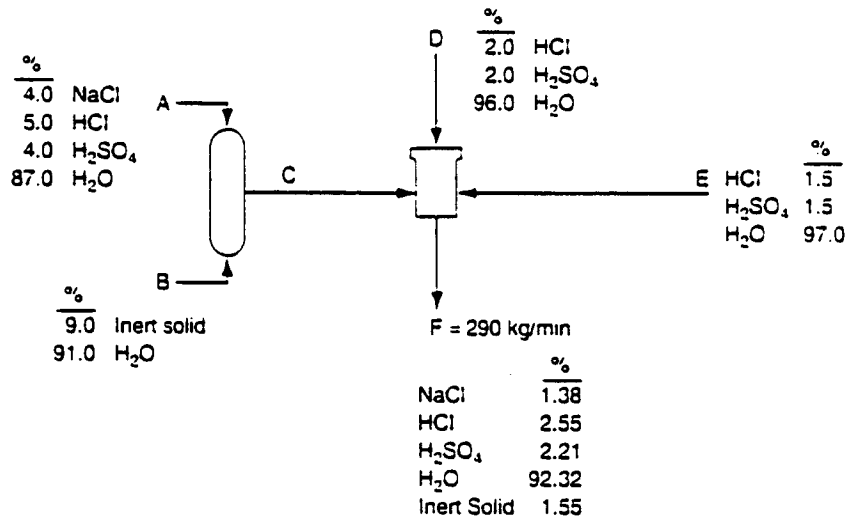


Jika slag (produk pepejal) mengandungi 80% FeO dan 20% FeS, dan gas keluaran ialah 100% SO₂, tentukan darjah tindakbalas and bilangan mol FeS pada permulaan. Gunakan 100 kg sebagai dasar.

(10 markah)

- (b) Beberapa arus dicampur seperti ditunjukkan di Rajah 2. Hitung aliran setiap arus dalam kg/s.

(15 markah)



Rajah 2

(15 markah)

3. (a) Stim memasuki paip mendatar panjang dengan garispusat masukan $D_1=12$ cm pada 1 MPa dan 250°C dengan kelajuan 2 m/s. Di keluarannya, keadaan ialah pada 800 kPa dan 200°C dan garispusat keluaran $D_2 = 10$ cm. Tentukan:

- Kadar aliran jisim bagi stim
- Kadar pindahan haba

(15 markah)

- (b) Kirakan haba tindakbalas kimia untuk tindakbalas berikut:

- $\text{Na}_2\text{SO}_4 (\text{s}) + \text{C} (\text{s}) \rightarrow \text{Na}_2\text{SO}_3 (\text{s}) + \text{CO} (\text{g})$
- $\text{NaCl} (\text{s}) + 2\text{SO}_2 + 2\text{H}_2\text{O}(\text{l}) + \text{O}_2 (\text{g}) \rightarrow 2\text{Na}_2\text{SO}_4 (\text{s}) + 4 \text{HCl}(\text{g})$
- $\text{NaCl}(\text{s}) + \text{H}_2\text{SO}_4 (\text{l}) \rightarrow \text{NaHSO}_4 (\text{s}) + \text{HCl} (\text{g})$
- $\text{C}_2\text{H}_2 (\text{g}) + \text{H}_2\text{O} (\text{l}) \rightarrow \text{CH}_3\text{CHO} (\text{l})$

(10 markah)