SULIT

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENGAJIAN TINGGI

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI I : 2022 / 2023

DGP30132 : MASS AND ENERGY BALANCE

TARIKH : 15 DISEMBER 2022
MASA : 8.30 PAGI – 10.30 PAGI (2 JAM)

Kertas ini mengandungi **DUA BELAS (12)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Tiada

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** the questions

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan struktur. Jawab **SEMUA** soalan.*

QUESTION 1
SOALAN 1

CLO1
C1

(a) State **FOUR (4)** dimensions in basic concept of measurement.
*Nyatakan **EMPAT (4)** dimensi dalam pengukuran asas.*

[4 marks]
[4 markah]

CLO1
C2

(b) The specific gravity of formaldehyde is 0.815.
Spesifik graviti formaldehyde ialah 0.815.

i) Approximate the mass in kg for 3550 ml of formaldehyde.
Anggarkan jisim dalam kg bagi 3550 ml bagi formadehyde.

[5 marks]
[5 markah]

ii) Approximate the volumetric flow rate in ml/min corresponding to a mass flow rate of 65.0 Ib_m formaldehyde/hr.
Anggarkan kadar alir isipadu dalam ml/min berdasarkan kadar alir jisim 65.0lbm formaldehyde/jam.

[4 marks]
[4 markah]

CLO1
C3

c) The following contains 687.6 gram of pentane, C_5H_{12}. Given the atomic weight of carbon, C is 12.0 g/mol and hydrogen, H is 1.0 g/mol. Avogadro's number is $6.02x10^{23}$.
Berikut mengandungi 687.6 gram pentana , C_5H_{12}. Diberi berat atom karbon C ialah 12.0 g/mol dan hydrogen, H ialah 1.0 g/mol , Nombor Avogadro ialah $6.02x10^{23}$.

i) Calculate the number of mole pentane, C_5H_{12}.
Kirakan bilangan mol pentana, C_5H_{12}.

[4 marks]
[4 markah]

ii) Calculate the mass in gram(g) of H_2.
Kirakan jisim dalam gram(g) bagi H_2

[4 marks]
[4 markah]

iii) Calculate the number of atom C.
Kirakan bilangan atom C.

[4 marks]
[4 markah]

QUESTION 2
SOALAN 2

CLO1
C1

(a) Define the following:
Definisikan yang berikut:

i) Fractional conversion
Pecahan penukaran

[2 marks]
[2 markah]

ii) Selectivity
Keterpilihan

[2 marks]
[2 markah]

CLO2
C3

(b) 2400 kg/h of a mixture is fed to a continuous fractioning column analysis by weight with 68 % benzene and the balance is toluene. The analysis of the distillate shows 78 wt% benzene and 4 wt% benzene was found in the bottom product.

2400 kg/jam suatu campuran yang telah disuap ke dalam turus penyulingan berterusan yang mengandung 68% benzene dan selebih nya adalah toluene mengikut jisim. Analisis mendapati 78 wt% benzena hasil sulingan dan 4 wt% benzene terhasil pada aliran bawah.

i) Calculate the mass flow rate of distillate and bottom product.
Kirakan kadar alir jisim hasil penyulingan atas dan bawah.

[5 marks]
[5 markah]

ii) Calculate the percentage (%) recovery of benzene.
Kirakan peratus% benzena yang telah di perolehi.

[4 marks]
[4 markah]

CLO2 C3 (c) The feed to a continuous ammonia formation reactor is 150 mol/s nitrogen, 450mol/s hydrogen and 2.00 mol/s argon(inert gas). The fractional conversion of hydrogen in the reactor is 85%.
Suapan ke dalam reactor pembentukan ammonia berterusan adalah 150 mol/s gas nitrogen, 450 mol/s gas hydrogen dan 2.00 mol/s argon (gas lengai). "The Fractional conversion" bagi gas hydrogen d dalam reactor ialah 85%.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

i) Calculate the extent of reaction.
Kirakan takat tindak balas.

[6 marks]
[6 markah]

ii) Calculate the molar flow rate of each species as it exits the reactor.
Kirakan kadar alir molar bagi setiap species yang keluar daripada reaktor.

[6 marks]
[6 markah]

QUESTION 3
SOALAN 3

CLO1 C1

(a) Define the following terms.
Takrifkan istilah.

i) Ideal gas constant, R / *Pemalar gas ideal, R*

[2 marks]
[*2 markah*]

ii) Absolute pressure / *Tekanan mutlak*

[2 marks]
[*2 markah*]

CLO1 C2

(b) The absolute pressure of 100g nitrogen gas at 40 °C reads at 3 atm. Molecular weight of N_2 is 28 g/mol.
Tekanan multak bagi 100g gas nitrogen nitogen ialah 3 atm pada suhu 40 °C. Berat molekul nitrogen N_2 ialah 28 g/mol.

i) Approximate the volume of nitrogen gas in liter (L)
Anggarkan isipadu gas nitrogen dalam liter(L).

[4 marks]
[*4 markah*]

ii) Approximate the density of nitrogen in kg/m^3.
Anggarkan ketumpatan nitrogen dalam kg/m^3.

[4 marks]
[*4 markah*]

CLO1 C3

(c) An ideal gas mixture contains 35% of carbon dioxide, 20% of methane and 45% of nitrogen by mole at 240 kPa absolute and 90°C. The molar mass of CO_2, CH_4 and N_2 are 44.0, 16.0 and 28.0 kg/kmol, respectively.
Suatu campuran gas unggul mengandungi 35% karbon dioksida, 20% metana dan 45% nitrogen mengikut mol pada 240 kPa mutlak dan 90 ℃. Jisim molekul CO_2, CH_4 dan N_2 masing-masing ialah 44.0, 16.0 dan 28.0 kg/kmol.

i) Calculate the partial pressure of each component.
Kirakan tekanan separa setiap komponen.

[6 marks]
[*6 markah*]

ii) Calculate the mass fraction of each component.

Kirakan pecahan jisim setiap komponen.

[7 marks]
[*7 markah*]

QUESTION 4
SOALAN 4

CLO2
C1

(a) Give the S.I unit of the following:

Berikan unit S.I untuk yang berikut:

i) Kinetic Energy / *Tenaga kinetic*

[2 marks]
[*2 markah*]

ii) Internal Energy / *Tenaga dalaman*

[2 marks]
[*2 markah*]

CLO2
C2

(b) In a distillation train a hydrocarbon liquid containing 20 mole% ethane (C2), 30 mole % propane (C3) and 50 mole % butane (C4) is to be fractionated into essentially pure components as shown in **Diagram 4(b).**

*Dalam penyulingan berperingkat cecair hidrokarbon yang mengandungi 20 mol % etana(C2), 30 mol % propana(C3) and 50 mol % butana(C4) akan dipecahkan kepada komponen tulen seperti di dalam **Rajah 4(b)** di bawah.*

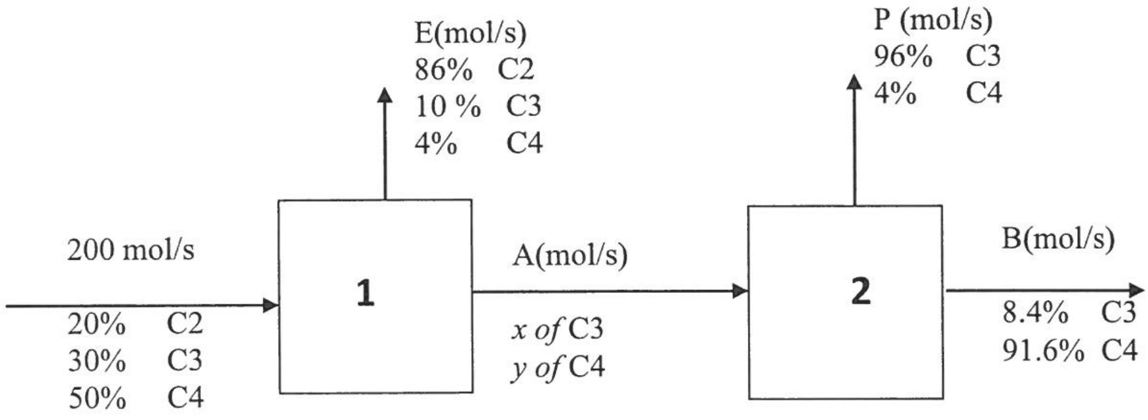

Diagram 4(b) / *Rajah 4(b)*

i) Calculate the unknown flow rates A, B, E and P.

Kirakan kadar alir A, B, E dan P.

[4 marks]
[4 markah]

ii) Calculate the composition of *x* and *y*.

Kirakan komposisi x dan y.

[4 marks]
[4 markah]

CLO2
C3

(c) i) Calculate the standard of heat for the reaction below by using Hess's Law and the given heats of reaction.

Tentukan haba tentu bagi tindak balas di bawah dengan mengunakan Hukum Hess.

$$2C + 3H_2 \rightarrow C_2H_6 \qquad \Delta\dot{H}_{r4}^{o} = ???$$

The Standard heats of the following combustion reactions have been determined experimentally:

Haba tentu bagi tindak balas pembakaran di bawah telah diperolehi dari ujikaji.

$$C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \qquad \Delta\dot{H}_{r1}^{0} = -1559.8kJ/mol$$

$$C + O_2 \rightarrow CO_2 \qquad \Delta\dot{H}_{r2}^{o} = -393.5kJ/mol$$

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \qquad \Delta\dot{H}_{r3}^{o} = -285kJ/mol$$

[4 marks]
[4 markah]

ii) The heat removal rate is required to cool the nitrous oxide from 100°C to 10° C is – 75000 kJ/h. The constant heat capacity of N_2O in this temperature range is given by the equation below. Where T is in °C. Calculate the specific internal energy, $\Delta\tilde{U}$ of the N_2O.

Kadar haba tersingkir diperlukan untuk menurunkan nitrogen oksida daripada 100℃ kepada 10° C ialah -75000 kJ/j. Nilai pemalar isipadu haba muatan N_2O untuk julat suhu tersebut diberi dalam persamaan di bawah. Di mana T dalam ℃. Kirakan tenaga dalaman tentu ,$\Delta\tilde{U}$ bagi N_2O.

$$C_p(kJ/mol.^{o}C) = 0.855 + 9.42\times10^{-4}T$$

[5 marks]

[5 markah]

iii) Calculate the mass flow rate in g/s required to raise the N_2O based on C(ii). Molecular weight of N_2O is 44.0g/mol .

Kirakan kadar alir jism dalam g/s yang diperlukan untuk memanaskan N_2O berdasarkan C(ii). Berat molekul N_2O ialah 44.0 g/mol.

[4 marks]

[4 markah]

SOALAN TAMAT

Appendix 1

Table of Unit Conversions

Quantity	Equivalent Values
Mass	1 kg = 1000 g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz 1 lb_m = 16 oz = 5 X 10^{-4} ton = 453.593 g = 0.453593 kg
Length	1 m = 100 cm = 1000 mm = 10^6 microns (μm) = 10^{10} angstroms (A) = 39.37 in. = 3.2808 ft = 1.0936 yd = 0.0006214 mile
Volume	1 m^3 = 1000 liters = 10^6 cm^3 = 10^6 ml = 35.3145 ft^3 = 220.83 imperial gallons = 264.17 gal = 1056.68 qt 1 ft^3 = 1728 in^3 = 7.4805 gal = 0.028317 m^3 = 28.317 liters = 28 317 cm^3
Force	1 N = 1 kg.m/s^2 = 10^5 dynes = 10^5 g.cm/s^2 = 0.22481 lb_f 1 lb_f = 32.174 lbm.ft/s^2 = 4.4482 N = 4.4482 X 10^4 dynes
Pressure	1 atm = 1.01325 x 10^5 N/m^2 (Pa) = 101.325 kPa = 1.01325 bars = 1.01325 x 10^6 dynes/cm^2 = 760 mm Hg at 0 °C (torr) = 10.333 m H_2O at 4 °C = 14.696lb_f/in^2 (psi) = 33.9 ft H_2O at 4 °C = 29.921 in Hg at 0 °C
Energy	1 J = 1 N.m = 10^7 ergs = 10^7 dyne.cm = 2.778 x 10^{-7} kW.h = 0.23901 cal = 0.7376 ft-lb_f = 9.486 x 10^{-4} Btu
Power	1 W = 1J/s = 0.23901 cal/s = 0.7376 ft.lb_f/s = 9.468 x 10^{-4} Btu/s = 1.341 x 10^{-3} hp

Appendix ll

FORMULAS & EQUATIONS

CHAPTER 1

1. $W = mg$
2. $g = 9.8066\ m/s^2 = 980.66\ cm/s^2 = 32.174\ ft/s^2$
3. $SG = \rho\ /\ \rho_{ref}$
2. $\rho_{ref}\ (H_2O, 4^{\circ}C) = 1.000\ g/cm^3 = 1000\ kg/m^3 = 62.43\ lb_m/ft^3$
3. Density $\rho = m/V$
4. Avogadro's Number = 6.02×10^{23}
5. $$number\ of\ moles = \frac{mass}{Molecular\ weight}$$
6. $$Mass\ Fraction, x = \frac{m}{m_{Total}} \quad \text{and} \quad Mole\ Fraction, y = \frac{n}{n_{total}}$$

CHAPTER 2

1. General Balance Equation for steady state process:

   input + generation = output + consumption

2. $$Frational\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}}$$
3. $$percentage\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}} \times 100\%$$
4. $$fractional\ conversion, f = \frac{moles_{(reacted)}}{moles_{(Fed)}}$$
5. $$\%fractional\ conversion = \frac{moles_{(reacted)}}{moles_{(Fed)}} \times 100\%$$
6. $$Yield = \frac{moles_{(desired\ product)}}{moles_{(LR)}} \times \frac{stoichiometry\ coefficient_{(LR)}}{stoichiometry\ coefficient_{(DP)}} \times 100\%$$

7 $Selectivity = \frac{moles_{(desired\ product)}}{moles_{(undesired\ product)}}$

8 Percentage excess air = $\frac{(\text{moles air})_{fed} - (\text{moles air})_{theoretical}}{(\text{moles air})_{theoretical}}$ X 100 %

9 100 mol air ⟶ 79 mol nitrogen
⟶ 21 mol oxygen

CHAPTER 3

1. Ideal gas law : PV = nRT : $\frac{PV}{P_sV_s} = \frac{nT}{n_sT_s}$: $\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$

2. $P_{absolute} = P_{atmospheric} + P_{gauge}$

3. Gas constant, R = 8.314 m^3.Pa / mol .K = 0.08314 liter.bar / mol . K =0.08206 liter.atm/mol.K = 63.36 liter.mm Hg/mol.K = 0.7302 ft^3.atm/Ib-mole.°R = 10.73 ft^3 .psia / Ib-mole . °R = 8.314 J/mol.K = 1.987 cal/mol.K = 1.987 Btu / Ib-mole. °R

4. T (K) = T (° C) + 273
T (°R) = T (°F) + 460
T(°F) = $T(°C)\frac{5}{9}$ + 32

5. Standard Condition for gases

System	T_s	P_s	V_s	n_s
SI	273 K	1 atm	0.022415 m^3	1 mol

6. Vs/ns = 0.0224 m^3 (STP)/mol = 22.4 liters(STP)/mol = 359 ft^3(STP)/Ib-mole

CHAPTER 4

1. Kinetic Energy $= \frac{1}{2} mv^2$
2. Potential Energy = mgh
3. First Law of Thermodynamics for closed system:

$$\Delta U + \Delta E_{kinetic} + \Delta E_{potential} = Q + W$$

4. Energy balance for closed system:

$$Q = \Delta U = m\,\Delta\tilde{U}$$

5. Specific internal energy, $\Delta\hat{U} = \int_{T_1}^{T_2} Cv(T)dT$
6. Heat of reaction $\Delta H = \sum n\,\Delta H_{(products)} - \sum n \Delta H_{(reactants)}$