SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

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

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI II : 2023/2024

DGP30132 : MASS AND ENERGY BALANCE

TARIKH : 05 JUN 2024
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **SEPULUH (10)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Appendix

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

(a) State the S.I unit of the velocity.

Nyatakan unit S.I untuk halaju.

[2 marks]

[2 *markah*]

CLO1

(b) i) Butane can be used as a replacement for CFCs in refrigerators. The specific gravity of butane is 0.6. Approximate the volume in gallon(gal) needed to contain 550.0 g of butane.

Butana boleh digunakan untuk menggantikan CFCs dalam peti sejuk. Specifik graviti butana ialah 0.6. Anggarkan isipadu dalam unit gallon(gal) yang menggandungi 550.0 gram butana.

[5 marks]

[5 *markah*]

ii) A density of copper is 8.96 g/mL. The initial level of water in the graduated cylinder rises from 325 mL to 815 mL after a piece of copper is submerged. Approximate the mass of copper in kg.

Ketumpatan kuprum ialah 8.96 g/mL. Paras awal air di dalam silinder penyukat naik dari 325mL kepada 815mL selepas sekeping kuprum direndam. Anggarkan jisim kuprum dalam unit kg.

[5 marks]

[5 *markah*]

CLO1

(c) Liquid methanol is flowing through a pipe at a rate of 75 m^3/hr. Molecular weight of methanol is 32.0 g/mol and the specific gravity of methanol is 0.791.
Cecair metanol mengalir dalam pipe dengan kadar 75 m^3/hr. Berat molekul methanol ialah 32.0 g/mol dan specific gravity methanol ialah 0.791.

i) Calculate the density of methanol.
Kirakan ketumpatan methanol.

[4 marks]
[4 markah]

ii) Calculate the mass flow rate of this stream in kg/min.
Kirakan kada ralir jisim bagi aliran ini dalam kg/min.

[4 marks]
[4 markah]

iii) Calculate the molar flow rate in mol/s.
Kirakan kadar alir molar dalam mol/s.

[5 marks]
[5 markah]

QUESTION 2
SOALAN 2

CLO2

(a) State **TWO (2)** differences between complete combustion and incomplete combustion by giving an appropriate example.
*Nyatakan **DUA (2)** perbezaan antara pembakaran lengkap dan pembakaran tidak lengkap dengan memberikan satu contoh yang sesuai.*

[4 marks]
[4 markah]

CLO2

(b) The diagram 2(b) describes a mixing tank of three streams.
Rajah 2(b) menerangkan suatu tangki campuran bagi tiga aliran.

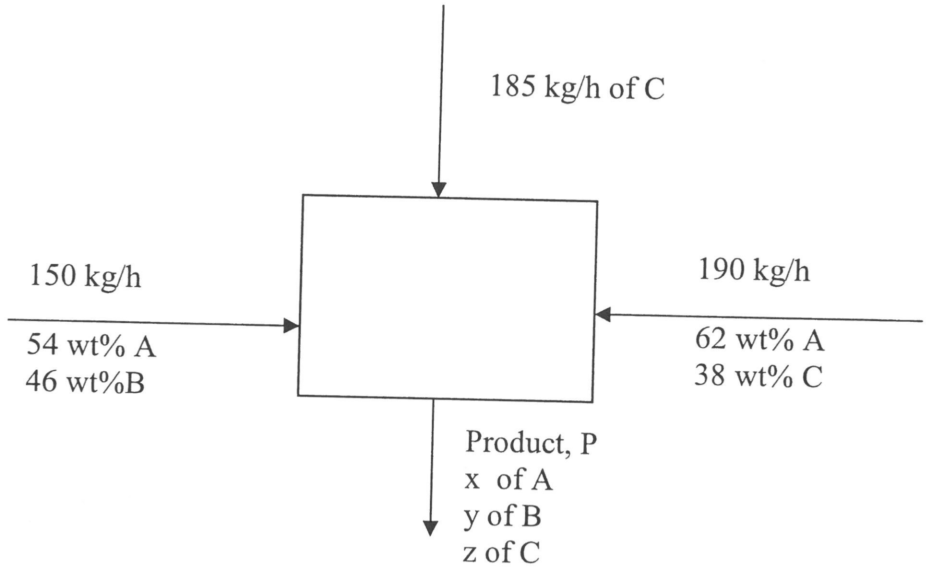

Diagram 2(b)/*Rajah 2(b)*

i) Calculate the mass of product, P.
Kirakan jisim produk P.

[4 marks]
[*4 markah*]

ii) Calculate the composition (%) of each component A, B and C in the product stream.
Kirakan komposisi (%) setiap komponen A, B dan C di dalam aliran produk.

[5 marks]
[*5 markah*]

CLO2

(c) Ethylene oxide is produced by the catalytic oxidation of ethylene. The feed to a reactor contains 200 kmol C_2H_4 and 200 kmol O_2. The fractional conversion of limiting reactant is 85%. The reaction is stated as below;

Etilena oksida terhasil daripada pengoksidaan bermangkin. Suapan ke reaktor mengandungi 200 kmol C_2H_4 dan 200 kmol O_2. 'Fractional conversion' bahan tindak balas terhad ialah 85%. Tindak balas seperti di bawah.

$$2C_2H_4 + O_2 \rightarrow 2C_2H_4O$$

i) Calculate the percentage (%) of the excess reactant.

Kirakan peratus (%) bahan yang berlebihan.

[5 marks]

[*5 markah*]

ii) Calculate the mole of all products in the output stream.

Kirakan bilangan mol semua produk dalam aliran keluar.

[7 marks]

[*7 markah*]

QUESTION 3

SOALAN 3

CLO1

(a) Define the following terms.

Takrifkan istilah.

i) Partial pressure

Tekanan separa

[2 marks]

[*2 markah*]

ii) Ideal Gas Equation of State

Persamaan Asas Ideal Gas

[2 marks]

[*2 markah*]

CLO1

(b) Ammonia (NH_3) gas can be synthesized from the complete reaction of 8.5 kg of hydrogen,H_2 (g) and nitrogen, N_2(g) at pressure 3.5 atm(abs) and 75°C . Molecular weight of H_2 is 2.0 g/mol. Assume ammonia is an ideal gas.

Gas ammonia (NH_3) boleh disintesis daripada tindak balas lengkap 8.5 kg gas hidrogen, H_2 (g) dan gas nitrogen, N_2(g) pada tekanan 3.5 atm(abs) dan suhu 75°C. Berat molekul H_2 ialah 2.0 g/mol. Anggapkan ammonia ialah gas ideal.

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

i) Approximate the mole of hydrogen and ammonia.

Anggarkan bilangan mol hidrogen dan ammonia.

[4 marks]

[*4 markah*]

ii) Approximate the volume in m^3 of ammonia, NH_3 .

Anggarkan isipadu dalam m^3 ammonia NH_3..

[4 marks]

[*4 markah*]

CLO1

(c) i) Calculate the value of gas constant,R in (liter.atm/mol.K) occupied by 115 liters, 355 g of butane gas at 23°C and 18.7 psi(abs) assuming ideal gas behaviour. Molecular weight of butane is 58 g/mol.

Kirakan nilai pemalar gas R dalam (liter.atm/mol.K) yang mengandungi 115 liters dan 355 g gas butana pada 23°C and 18.7 psi (abs) dengan menganggap gas bersifat ideal. Berat molekul butana ialah 58 g/mol.

[6 marks]

[6 *markah*]

CLO1

ii) Hexane (C_6H_{14}) at 300°C and 4 atm (gauge) flows into a reactor at a rate of 220kg/hr. Calculate the volumetric flow rate of this stream in m^3/hr by using conversion of standard condition. Molecular weight Hexane (C_6H_{14}) is 86.0 g/mol.

Heksana (C_6H_{14}) pada 300℃ dan 4 atm(gauge) mengalir ke dalam reaktor pada kadar 220kg/jam. Kirakan kadar alir isipadu dalam in m^3/jam menggunakan 'conversion of standard condition' Berat molekul Heksana (C_6H_{14}) ialah 86.0 g/mol.

[7 marks]

[7 markah]

QUESTION 4

SOALAN 4

CLO2

(a) Define the following terms:

Difinasikan istilah berikut:

i) Hess's Law

Hukum Hess

[2 marks]

[2 markah]

ii) Heat of Reaction

Tenaga tindak balas

[2 marks]

[2 markah]

CLO2

(b) In a distillation train a mixture contains 45% of component A and 55% of component B is to be fractionated into essentially pure components as shown in the **Diagram 4(b).**

*Dalam penyulingan berperingkat suatu campuran yang mengandungi 45% komponen A dan 55 % komponen B akan disulingkan kepada komponen tulen seperti di dalam **Rajah 4(b)** di bawah.*

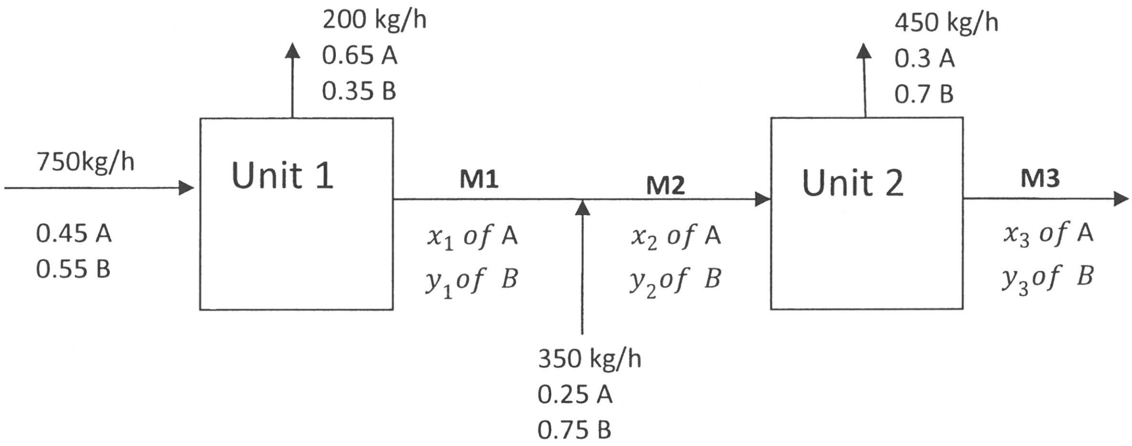

Diagram 4(b)/*Rajah 4(b)*

CLO2

i) Approximate the flow rates of M1, M2 and M3.

Anggarkan kadar alir M1, M2 dan M3.

[4 marks]

[4 markah]

ii) Approximate the composition (%) of component A and B in all the unknown flow rates.

Anggarkan *komposisi (%) komponen A dan B dalam semua kadar alir yang tidak diketahhui.*

[4 marks]

[4 markah]

CLO2

(c) i) Calculate the heat of reaction, ΔH(kJ) at 298K for the following reaction
using the listed standard enthalpy of reaction data using Hess's law.
Kirakan haba tindak balas, ΔH(kJ) at 298K bagi tindak balas di bawah dengan mengunakan Hukum Hess.

$$N_2H_4(l) + CH_4O(l) \rightarrow CH_2O(g) + N_2(g) + 3H_2(g)$$

The standard enthalpy of the following reactions have been determined experimentally:
Haba tentu bagi tindak balas di bawah telah diperolehi dari ujikaji.

$2NH_3(g) \rightarrow N_2H_4(l) + H_2(g)$	ΔH = 22.5 kJ
$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$	ΔH = 57.5 kJ
$CH_2O(g) + H_2(g) \rightarrow CH_4O(l)$	ΔH = 81.2 kJ

[4 marks]
[*4 markah*]

CLO2

ii) The heat removal rate is required to cool the nitrous oxide from 25°C to 120°C is 58000 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 25°C kepada 120° C ialah 58000 kJ/h. Nilai pemalar isipadu haba muatan N_2O untuk julat suhu tersebut diberi dalam persamaan di bawah.. Di mana T dalam °C. Kirakan tenaga dalaman tentu ,$\Delta\tilde{U}$ bagi N_2O.

$$C_p(kJ/mol.\,^oC) \quad = 0.855 + 9.42 \times 10^{-4}T$$

[5 marks]
[5 *markah*]

CLO2

iii) Calculate the mass flow rate required in g/s to raise the N_2O based on C(ii). Molecular weight of N_2O is 44.0 g/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 Ib_m = 35.27392 oz 1 Ib_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 Ib_f 1 Ib_f = 32.174 Ibm.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

1. W = mg, F=mg
2. $g = 9.8066\ m/s^2 = 980.66\ cm/s^2 = 32.174\ ft/s^2$
3. $SG = \rho / \rho_{ref}$
2. ρ_{ref} ($H_2O, 4^\circ C$) = 1.000 g/cm^3 = 1000 kg/m^3 = 62.43 Ib_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. $Mass\ Fraction, x = \frac{m}{m_{Total}}$ and $Mole\ Fraction, y = \frac{n}{n_{total}}$
7. General Balance Equation for steady state process:

   input + generation = output + consumption

8. $$Frational\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}}$$
9. $$percentage\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}} \times 100\%$$
10. $$fractional\ conversion, f = \frac{moles_{(reacted)}}{moles_{(Fed)}}$$
11. $$\%fractional\ conversion = \frac{moles_{(reacted)}}{moles_{(Fed)}} \times 100\%$$
12. $$Yield = \frac{moles_{(desired\ product)}}{moles_{(LR)}} \times \frac{stoichiometry\ coefficient_{(LR)}}{stoichiometry\ coefficient_{(DP)}} \times 100\%$$
13. $$Selectivity = \frac{moles_{(desired\ product)}}{moles_{(undesired\ product)}}$$

14. Percentage excess air = $\dfrac{(\text{moles air})_{\text{fed}} - (\text{moles air})_{\text{theoretical}}}{(\text{moles air})_{\text{theoretical}}}$ X 100 %

15. 100 mol air ⟶ 79 mol nitrogen

⟶ 21 mol oxygen

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

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

18. 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

19. T (K) = T (˚C) + 273

T (˚R) =T (˚F) + 460

$T(°F) = T(°C)\dfrac{5}{9} + 32$

20. Standard Condition for gases

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

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

22. Kinetic Energy = ½ mv^2

23. Potential Energy = mgh

24. First Law of Thermodynamics for closed system:

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

25. Energy balance for closed system:

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

26. Specific internal energy, $\Delta\hat{U} = \int_{T_1}^{T_2} Cv(T)dT$

27. Heat of reaction $\Delta H = \sum n\,\Delta H_{(products)} - \sum n \Delta H_{(reactants)}$