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 : 2022/2023

DGP30132 : MASS AND ENERGY BALANCE

TARIKH : 22 JUN 2023
MASA : 8.30 PG - 10.30 PG (2 JAM)

Kertas ini mengandungi **TIGA BELAS (13)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This section consists of **FOUR (4)** questions. Answers **ALL** questions.

ARAHAN:

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

QUESTION 1

SOALAN 1

CLO1

(a) Derived dimensions or units are developed from the fundamental dimensions or units. State **ONE (1)** derived dimension with the correct SI unit.

*Dimensi terbitan atau unit dibangunkan daripada dimensi asas atau unit asas. Nyatakan **SATU (1)** dimensi terbitan bersama unit SI yang betul.*

[2 marks]

[*2 markah*]

CLO1

(b) Flow rate is the rate at which a material is transported through a process line or pipes. Discuss the following flow rate:

Kadar aliran adalah aliran di mana bahan dipindahkan melalui laluan atau paip proses. Bincangkan kadar aliran berikut:

i) Molar flow rate

Kadar aliran molar

[5 marks]

[*5 markah*]

ii) Mass flow rate

Kadar aliran jisim

[5 marks]

[*5 markah*]

CLO1

(c) A liquefied mixture of n-butane, n-pantane and n-hexane has the following composition:

Campuran cecair n-butana, n-pantana dan n-heksana mempunyai komposisi berikut:

$n\text{-}C_4H_{10}$	50%
$n\text{-}C_5H_{12}$	30%
$n\text{-}C_6H_{14}$	20%

For this mixture, calculate:

Untuk campuran ini, kirakan:

i) The molecular weight of each component.
Berat molekul bagi setiap komponen.

[4 marks]
[*4 markah*]

ii) The moles of each component.
Mol bagi setiap komponen.

[4 marks]
[*4 markah*]

iii) The mole fraction of each component.
Pecahan mol bagi setiap komponen.

[5 marks]
[*5 markah*]

QUESTION 2

SOALAN 2

CLO2

(a) Define the terms below:
Takrifkan terma-terma dibawah:

i) Limiting reactant / *Reaktan penghad*

[2 marks]
[*2 markah*]

ii) Theoretical oxygen / *Oksigen secara teori*

[2 marks]
[*2 markah*]

CLO2

(b) Methane (CH_4) and oxygen (O_2) react in the presence of a catalyst to form formaldehyde (HCHO). In a parallel reaction, methane is oxidized to form carbon dioxide and water. The feed to a plug flow reactor contains equimolar amounts of methane and oxygen. The fractional conversion of methane is 0.92, and the fraction yield of formaldehyde is 0.88. Assume a basis of 100 mol feed/s:

Metana (CH_4) dan oksigen (O_2) bertindak balas dengan kehadiran pemangkin untuk menghasilkan formaldehid (HCHO). Dalam tindak balas yang selari, metana dioksidakan menjadi karbon dioksida dan air. Suapan masuk ke dalam reaktor aliran palam mengandungi jumlah yang mol yang sama antara metana dan oksigen. Pecahan penukaran metana adalah 0.92 dan pecahan hasil formaldehid adalah 0.88. Andaikan basis suapan adalah 100 mol/s:

$$CH_4 + O_2 \rightarrow HCHO + H_2O$$

$$CH_4 + 2O_2 \rightarrow 2CO_2 + 2H_2O$$

i) Draw flowchart of the process and write the material balance equation for all components in terms of extents of reaction (ξ).

Lakarkan rajah alir proses dan tuliskan persamaan imbangan bahan bagi semua komponen dari terma jangkauan (ξ)tindak balas.

[4 marks]

[*4 markah*]

ii) Calculate the selectivity of formaldehyde production relative to carbon dioxide production.

Kirakan pemilihan penghasilan formaldehid relatif kepada penghasilan karbon dioksida.

[5 marks]

[5 *markah*]

CLO2

(c) Consider the combustion process of coal as shown in Figure 2 (c) and the following reactions are taking place:

Proses pembakaran arang seperti Rajah 2 (c) dan tindak balas yang terlibat adalah seperti berikut:

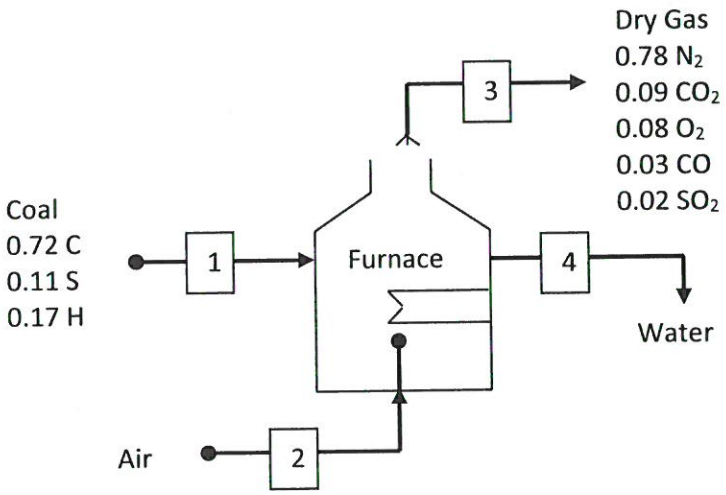

Diagram 2(c) / *Rajah 2(c)*

$$C + O_2 \rightarrow CO_2$$

$$S + O_2 \rightarrow SO_2$$

$$2H + 1/2O_2 \rightarrow CO_2$$

i. Calculate the flow rate and the composition of all streams and the moles of oxygen required for a complete combustion of C, S and H.

Kira kadar aliran dan komposisinya bagi semua aliran dan mol oksigen untuk satu pembakaran lengkap bagi C, S, dan H.

[6 marks]

[*6 markah*]

ii. Calculate the percentage of excessive air and the ratio of water vapor and dry gas by assuming all the coals are already consumed. Note that the feed composition is given in mole fractions.

Kira peratus udara berlebihan dan nisbah wap air dan gas kering dengan menganggap kesemua arang telah digunakan. Komposisi suapan diberi dalam pecahan mol.

[6 marks]

[*6 markah*]

QUESTION 3

SOALAN 3

CLO1 (a) i) Define the density of gas.

Takrifkan ketumpatan gas.

[2 marks]

[*2 markah*]

ii) Describe the equation of ideal state gas.

Terangkan persamaan keadaan gas unggul.

[2 marks]

[*2 markah*]

(b) Explain how the factors below affect density:

CLO1 *Terangkan bagaimana faktor-faktor di bawah memberi kesan kepada ketumpatan:*

i) Temperature / *Suhu*

[4 marks]

[*4 markah*]

ii) Phase of matter / *Fasa jirim*

[4 marks]

[*4 markah*]

CLO1 (c) i) A well-insulated tank has a volume of 10L and initially filled with 500g Nitrogen (N_2) until it reached 50% of the volume of the tank. After a while, the tank is filled up with 300g of oxygen until it is full. Calculate the partial pressure of each gas at 20°C after it is fully filled up, and calculate the total pressure in the tank at this temperature.

Sebuah tangki mempunyai isipadu 10L dan diisi dengan 500g Nitrogen (N_2) sehingga ia mencapai 50% dari isipadu tangki. Selepas seketika, tangki diisi dengan 300g oksigen sehingga penuh. Kirakan tekanan separa untuk setiap gas pada 20°C selepas ia diisi hingga penuh, dan kirakan jumlah tekanan di dalam tangki pada suhu tersebut.

[6 marks]

[*6 markah*]

ii) Carbon dioxide (CO_2) enters a fuel cell stack at rate 10g/s and at a temperature and pressure of 35°C and 10 atm respectively. Calculate the volumetric flow rate of oxygen in m^3/h converting it from standard condition.
Karbon dioksida (CO_2) memasuki timbunan sel bahan api dengan kadar 10g/s pada suhu dan tekanan 35°C dan 10 atm. Kirakan kadar alir isipadu oksigen dalam m^3/j dengan tukaran keaadaan piawai.

[7 marks]
[*7 markah*]

QUESTION 4
SOALAN 4

CLO2 (a) There are three forms of energy, which are kinetic energy, potential energy, internal energy.
Terdapat tiga bentuk tenaga, iaitu tenaga kinetik, tenaga potensi dan tenaga dalam.

i) Define the potential energy term / *Takrifkan istilah tenaga potensi*

[2 marks]
[*2 markah*]

ii) State the formula of potential energy / *Nyatakan formula tenaga potensi.*

[2 marks]
[*2 markah*]

CLO2 (b) 100mol of butane is fed into a burner chamber with 30% excess air. Assuming complete combustion occurs.
100mol butana dimasukkan ke dalam ruang pembakar dengan udaa berlebihan 30%. Dengan mengandaikan pembakaran lengkap berlaku.

i) Approximate the total mol of air fed into burner chamber
Anggarkan jumlah mol udara yang dimasukkan ke dalam ruang pembakar.

[4 marks]
[*4 markah*]

ii) In stack gas of burner chamber contains 74% N_2, 9% CO_2, 5% O_2 and the balance H_2O. Approximate the composition of the gas on an orsat analysis (dry basis).

Dalam timbunan gas ruang pembakar mengandungi 74% N_2, 9% CO_2, 5% O_2 and baki H_2O. Anggarkan komposisi gas pada analisis orsat (asa kering).

[4 marks]

[*4 markah*]

CLO2 (c) Based on the situation given:

Berdasarkan situasi yang diberikan:

i) Calculate the Δ Hrxn for the following reaction:

Kirakan Δ Hrxn untuk tindak balas berikut:

$$4NH_3\,(g\,) + 5O_2\,(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Given the following ΔH o/mole at 25°C.

Diberi ΔH o/mol pada 25°C.

NH_3 (g): -56.191 kJ/ mol

NO(g): +90.374 kJ/mol

H_2O (g): -200.045 kJ/mol

[4 marks]

[*4 markah*]

ii) Superheated steam at 300°C and 1 atm (absolute) is to be fed to a heat exchanger. It is produced by mixing an available stream of saturated steam at 1 atm discharged from turbine at a rate of 2100 kg/h with a second stream of superheated steam at 400 °C and 1 atm. The mixing may be considered adiabatic. Draw and label the flowchart diagram for the reaction process. Calculate the amount of superheated steam at 300 °C produced and the required volumetric flow rate of the 400 °C steam.

Wap yang dipanaskan lampau pada 300°C dan 1 atm (mutlak) hendaklah disalurkan kepada penukar haba. Ia dihasilkan dengan mencampurkan aliran stim tepu yang tersedia pada 1 atm yang dinyahcas daripada turbin pada kadar 2100 kg/j dengan aliran kedua stim panas lampau pada 400 °C dan 1 atm. Campuran boleh dianggap adiabatik. Lukis dan label gambarajah carta alir untuk proses tindak balas. Kira jumlah wap panas lampau pada 300 °C yang dihasilkan dan kadar aliran isipadu yang diperlukan bagi stim 400 °C.

[5 marks]

[*5 markah*]

iii) Water flows into a process unit through a 2.5cm ID pipe at a rate of 3.5 m^3/h. Calculate kinetic energy (E_k)for this stream in joules/second.

Aliran air ke dalam unit proses melalui paip ID 2.5cm pada kadar 3.5 m^3/j. Kira tenaga kinetik (E_k)untuk aliran ini dalam joule/saat.

[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 II

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. $\rho_{ref}\ (H_2O, 4°C) = 1.000\ g/cm^3 = 1000\ kg/m^3 = 62.43\ lb_m/ft^3$
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 $\Delta H = \sum n \Delta H_{(products)} - \sum n \Delta H_{(reactants)}$