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 I : 2024 / 2025

DGP30132 : MASS AND ENERGY BALANCE

TARIKH : 23 NOVEMBER 2024
MASA : 11.30 PAGI - 1.30 PETANG (2 JAM)

Kertas ini mengandungi **SEMBILAN (9)** 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)** structured questions. Answer **ALL** questions.

ARAHAN:

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

QUESTION 1

SOALAN 1

CLO1 (a) Define the density.

Takrifkan ketumpatan.

[2 marks]

[*2 markah*]

CLO1 (b) Gasoline is flowing through a pipe at a rate of 650 m^3/h. Molecular weight of gasoline is 145 g/mol. Specific gravity of gasoline is 0.739.

Gasolin mengalir melalui paip dengan kadar 650 m^3/h . Berat molekul gasoline ialah 145 g/mol. Graviti tentu gasoline ialah 0.739.

i) Approximate mass flow rate of the stream in kg/min.

Anggarkan kadar alir jisim bagi aliran ini dalam kg/min.

[5 marks]

[*5 markah*]

ii) Approximate the molar flow rate in mol/s.

Anggarkan kadar alir molar dalam mol/s.

[5 marks]

[*5 markah*]

CLO1

(c) A mixture of gas stream consists of 35 mole% ethyl alcohol and 65 mole% Ethyl Acetate. Given the molecular weight of ethyl alcohol is 46 g/mol and Ethyl Acetate is 88 g/mol. Take a 100 mol sample as a basis.

Satu aliran gas campuran terdiri daripada 35mol% etil alkohol dan 65mol% etil asetat. Diberi berat molekul etil alkohol ialah 46 g/mol dan etil asetat ialah 88 g/mol. Ambil 100 mol campuran sebagai asas pengiraan.

i) Calculate the mass composition of each component.
Kirakan komposisi jisim bagi setiap komponen.

[4 marks]
[*4 markah*]

ii) Calculate the molecular weight of the mixture.
Kirakan berat molekul campuran.

[4 marks]
[*4 markah*]

iii) Use the value in **b(ii),** calculate the molar concentration of ethyl alcohol (in mol/m^3), if the volume of the mixture is 2.5 liters and the total mass of the mixture is 2.5 kg.
*Guna nilai dalam **b(ii),** kirakan kepekatan molar etil alkohol (dalam mol/m^3), jika jumlah campuran adalah 2.5 liter dan jumlah jisim campuran adalah 2.5 kg.*

[5 marks]
[*5 markah*]

QUESTION 2

SOALAN 2

CLO2 (a) Process is the set of tasks or operations that accomplish a chemical or material transformation to produce a product. Define the following terms:

Proses ialah set tugas atau operasi yang mencapai transformasi kimia atau bahan untuk menghasilkan produk. Takrifkan

i) Batch Process

Proses Berkelompok

ii) Semi Batch Process

Proses Separa Berkelompok

[4 marks]

[*4 markah*]

CLO2 (b) A mixture of phenol-water forms two separate liquid phases, one rich in phenol and the other rich in water, the composition of layers is 75% and 7% phenol respectively (by weight). If 400kg of phenol and 700kg of water are mixed and layers allowed to separate.

Campuran fenol-air membentuk dua fasa cecair yang berasingan, satu kaya dengan fenol dan yang lain kaya dengan air, komposisi lapisan masing – masing adalah 75% dan 7% fenol (mengikut berat). Sekiranya 400kg fenol dan 700kg air dicampur dan lapisan dibenarkan untuk dipisahkan.

i) Draw a flowchart of the process with complete labelling.

Lukiskan carta alir proses dengan penglabelan lengkap.

[4 marks]

[4 *markah*]

ii) Calculate the mass of the two layers.

Kirakan jisim kedua - dua lapisan.

[5 marks]

[5 *markah*]

CLO2

(c) The dehydrogenation reaction takes place in a continuous reactor under a steady state. The feed stream contains 75.0 mole% ethane (C_2H_6) and the rest is nitrogen (N_2) as an inert gas. The fractional conversion of ethane is 0.856. Take a 100 mol feed as a basic calculation.

Reaksi dehidrogenasi berlaku dalam reactor berterusan di bawah keadaan stabil. Aliran suapan mengandungi 75 mol% etana (C_2H_6) dan selebihnya adalah nitrogen (N_2) gas lengai. Penukaran pecahan etana ialah 0.856. Ambil suapan 100 mol sebagai asas pengiraan.

$$C_2H_6\,(g) \rightarrow C_2H_4\,(g) + H_2\,(g)$$

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

[6 marks]
[*6 markah*]

ii) Calculate the moles of the product gas.
Kirakan mol produk gas.

[6 marks]
[*6 markah*]

QUESTION 3
SOALAN 3

CLO1 (a) Define the following terms.
Takrifkan perkara berikut.

i) Gas Constant, R
Pemalar Gas, R

ii) Ideal gas mixture
Campuran gas yang ideal

[4 marks]
[*4 markah*]

CLO1 (b) 200kg of methyl chloride (CH_3Cl) vapor is contained in a storage vessel at 100°C and compressed at 12 atm. Given the molecular weight of methyl chloride is 50.5kg/kmol and use gas constant, R = 0.08206 atm.L/mol.K
200kg wap metil klorida (CH_3Cl) terkandung dalam bekas simpanan pada 100°C dan dimampatkan pada 12 atm. Diberikan berat molekul metil klorida adalah 50.5kg/kmol dan menggunakan pemalar gas, R = 0.08206 atm.L/mol.K

i) Calculate the volume of methyl chloride vapor by using ideal gas equation.
Kirakan isipadu wap metil klorida menggunakan persamaan gas ideal.

[4 marks]
[*4 markah*]

ii) Calculate the volume of methyl chloride by using the standard condition equation as a comparison.
Kirakan isipadu metil klorida menggunakan persamaan keadaan standard sebagai perbandingan.

[4 marks]
[*4 markah*]

CLO1

(c) A stream of air (21 mole% and the rest is N_2) flows at a rate of 200 mol/h and it is mixed with a stream of CO_2 at a rate of 20 m^3/h at 150°C and 2atm. Then, the mixture gases are stored in the container at absolute pressure of 8 bars. By assuming the ideal gas system and use gas constant, R = 0.08206 atm.L/mol.K. The block flow diagram as shown in Figure 3(c).

Aliran udara (21 mol% dan selebihnya adalah N_2) yang mengalir pada kadar 200 mol/j dan ia bercampur dengan aliran CO_2 pada kadar 20m^3/j pada 150°C dan 2 atm. Kemudian, gas campuran disimpan dalam bekas pada tekanan mutlak 8 bar. Dengan menganggap sistem gas yang ideal dan menggunakan pemalar gas, R = 0.08206 atm.L/mol.K. Dengan gambarajah aliran blok adalah seperti dalam Rajah 3(c).

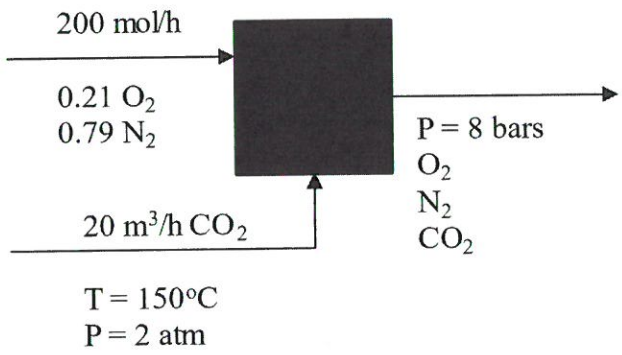

Figure 3(c)/*Rajah 3(c)*

i) Calculate the mole fraction of mixture gases.
Kirakan pecahan mol gas campuran.

[7 marks]
[*7 markah*]

ii) Calculate the partial pressure (in atm) of each species.
Kirakan tekanan separa (dalam atm) setiap spesis.

[6 marks]
[*6 markah*]

QUESTION 4

SOALAN 4

CLO2 (a) Define the following items

Takrifkan perkara berikut

i) Kinetic Energy

Tenaga Kinetik

ii) Enthalpy

Entalpi

[4 marks]

[*4 markah*]

CLO2 (b) 200 mol of methane is burned with 30% excess air in a continuous steady-state combustion reactor to yield a mixture of carbon dioxide and water. Given the molecular weight of air is 29 g/mol and methane is 16 g/mol. The reactions taking place is

200 mol metana dibakar dengan 30% udara berlebihan dalam reaktor pembakaran dalam keadaan stabil yang berterusan untuk menghasilkan campuran karbon dioksida dan air. Diberikan berat molekul udara ialah 29g/mol dan metana ialah 16g/mol. Tindak balas yang berlaku ialah

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

i) Approximate the mass of air supplied to the reactor.

Anggarkan jisim udara yang dibekalkan kepada reaktor.

[4 marks]

[*4 markah*]

ii) Approximate the air-fuel ratio for this complete combustion of methane.

Anggarkan nisbah udara-bahan api untuk pembakaran lengkap metana.

[4 marks]

[*4 markah*]

CLO2

(c) (i) Calculate the heat combustion (kJ) of propane (C_3H_8) according to the heat formation given below:

Kirakan haba pembakaran (kJ) propana (C_3H_8) mengikut pembentukan haba yang diberikan di bawah:

$$C_3H_8\ (g) + 5O_2\ (g) \rightarrow 3CO_2\ (g) + 4H_2O\ (g)$$

Given:

Diberikan:

$3C + 4H_2 \rightarrow C_3H_8$ $\quad \Delta H_f = -103.8kJ$

$C + O_2 \rightarrow CO_2$ $\quad \Delta H_f = -393.5kJ$

$H_2 + 0.5O_2 \rightarrow H_2O$ $\quad \Delta H_f = -241.93kJ$

[4 marks]

[*4 markah*]

(ii) 120 kmol/h of propane liquid is flowing through a pipe to be heated from 10 °C to 120°C. The polynomial heat capacity formula for propane is given by the equation below. Calculate the specific internal energy, $\Delta\hat{U}$ (kJ/kmol) of propane.

120 kmol/j cecair propana mengalir melalui paip untuk dipanaskan dari 10 hingga 120°C. Formula kapasiti haba polinomial haba propana diberi di bawah. Kirakan tenaga dalaman tentu, $\Delta\hat{U}$ (kJ/kmol) *bagi propana.*

$$C_v\left(\frac{kJ}{kmol.°C}\right) = -4.04 + 0.3048T$$

[5 marks]

[*5 markah*]

(iii) Calculate the heat, Q (kJ/s) based on C(ii).

Kirakan haba Q(kJ/s) berdasarkan C(ii)

[4 marks]

[*4 markah*]

SOALAN TAMAT

Appendix 1

Table 1 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. $Specific\ Gravity, SG = \frac{\rho}{\rho_{ref}}$
4. $\rho_{ref}\ (H_2O, 4^\circ C) = 1.000\ g/cm^3 = 1000\ kg/m^3 = 62.43\ lb_m/ft^3$
5. $Density, \rho = \frac{m}{v} = \frac{\dot{m}}{\dot{v}}$
6. Avogadro's Number = 6.02×10^{23}
7. $number\ of\ moles = \frac{mass}{Molecular\ weight}$ OR $n = \frac{m}{M_r}\ or\ \dot{n} = \frac{\dot{m}}{M_r}$
8. $Mass\ Fraction, x = \frac{m}{m_{Total}}$ and $Mole\ Fraction, y = \frac{n}{n_{total}}$

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 (%) $= \dfrac{(\text{moles air})_{\text{fed}} - (\text{moles air})_{\text{theoretical}}}{(\text{moles air})_{\text{theoretical}}} \times 100\ \%$

9. 100 mol air (79 mol nitrogen and 21 mol oxygen)

CHAPTER 3

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

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

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)

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, $\Delta H = \sum n \, \Delta H_{(products)} - \sum n \Delta H_{(reactants)}$