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

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI JUN 2019

DGP3123: MASS AND ENERGY BALANCE

TARIKH : 02 NOVEMBER 2019
MASA : 2.30 PETANG – 4.30 PETANG (2 JAM)

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

Soalan Struktur (4 soalan)

Dokumen sokongan yang disertakan : Tiada

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

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 concepts of measurement.
*Nyatakan **EMPAT (4)** dimensi dalam pengukuran konsep asas.*

[4 marks]
[4 *markah*]

CLO1
C2

(b) i) A cylinder plastic is 100 mm long, and 50 mm in diameter. It has a mass of 1 kg. Determine its specific gravity and indicate whether it would float or sink in water.
Sebuah plastic silinder mempunyai panjang 100mm, diameter 50mm serta jisim 1 kg. Tentukan spesifik gravity dan nyatakan sama ada ia terapung atau tidak.

[4 marks]
[4 *markah*]

ii). Determine the potential energy in unit (ft) (lb_f) for a mass of 200 lb_m drum that hung as high as 15 feet above the ground.
Tentukan tenaga keupayaan (potential energy) dalam unit (ft) (lbf) bagi dram berjisim 200 lbm yang tergantung setinggi15 kaki di atas permukaan bumi.

[3 marks]
[3 *markah*]

iii). An airplane travels twice the speed of sound. (Assume the speed of sound is 2100 ft / s), determine the aircraft velocity in units of miles / h.

Sebuah kapal terbang bergerak dua kali ganda halaju bunyi. (Anggap halaju bunyi ialah 2100 ft/s), dapatkan halaju kapal terbang tersebut dalam unit batu/jam.

[3 marks]

[*3 markah*]

CLO1 C2 (c) A 0.70 molar solution of sulfuric acid (H_2SO_4) in water flows into a reactor at a rate of 2.35 m^3/min. The specific gravity of the solution is 1.03 (relative to water at 4 ^{0}C). Th.. molecular weight of H_2SO_4 is 98.0 g/mol

0.70 molar larutan asid sulfurik (H_2SO_4) di dalam air mengalir ke dalam reactor pada kadar 2.35 m^3/min. Spesifik gravity untuk larutan tersebut ialah 1.03 (relatif kepada air pada 4 ^{0}C). Berat molekul H_2SO_4 ialah 98.0 g/mol.

i) Calculate the mass concentration of H_2SO_4 in kg/m^3.

Kira kepekatan jisim H_2SO_4 dalam kg/m^3.

[3 marks]

[*3 markah*]

ii) Calculate the mass flow rate of H_2SO_4 in kg/s.

Kira kadar aliran jisim H_2SO_4 dalam kg/s.

[3 marks]

[*3 markah*]

iii) Calculate the mass fraction of H_2SO_4.

Kira pecahan jisim H_2SO_4.

[5 marks]

[*5 markah*]

QUESTION 2

SOALAN 2

CLO1
C1

(a) Process is a set of tasks or operation that accomplish a chemical or material transformation to produce a product. Define the

i) Process streams

ii) Process variables.

Proses adalah satu set tugas atau operasi yang melakukan sesuatu bahan kimia atau bahan transformasi untuk menghasilkan produk. Takrifkan

i) Aliran proses

ii) Pembolehubah proses.

[4 marks]

[*4 markah*]

CLO2
C3

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

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

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

[7 marks]

[7 *markah*]

ii) Calculate the percentage (%) benzene recovery.
Kirakan peratus(%) pengambilan semula benzena.

[3 marks]

[*3 markah*]

CLO2
C3

(c) 100 moles of CO_2 and 350 moles of H_2 were fed into the reactor. If 70 moles of CH_3OH was formed after the reaction is completed;

100 mol CO_2 dan 350 mol H_2 disuapkan ke dalam reactor. Jika 70 mol CH_3OH telah terbentuk selepas tindak balas selesai.

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$

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

Kirakan peratusan (%) bahan tindak balas berlebihan

[3 marks]

[3 *markah*]

(ii) Calculate all moles of products from the reactor.

Kirakan bilangan mol semua produk yang keluar dari reactor.

[6 marks]

[6 *markah*]

(iii) Determine the fractional conversion of H_2.

Tentukan 'the fractional conversion' bagi H_2.

[2 marks]

[2 *markah*]

QUESTION 3

SOALAN 3

CLO2
C1

(a) Define the following concentrations.

Takrifkan kepekatan berikut.

i) The mass concentration

Kepekatan jisim

[2 marks]

[2 *markah*]

ii) The molar concentration
Kepekatan molar

[2 marks]
[*2 markah*]

CLO2
C3

(b) A labelled flow chart of continuous steady state of two distillation processes is shown in Diagram 3(b) below. Each stream contains two or three components A, B and C.
Carta alir bagi proses penyulingan berterusan ditunjukkan dalam Rajah 3(b) di bawah. Setiap aliran mengandungi dua atau tiga komponen A, B dan C.

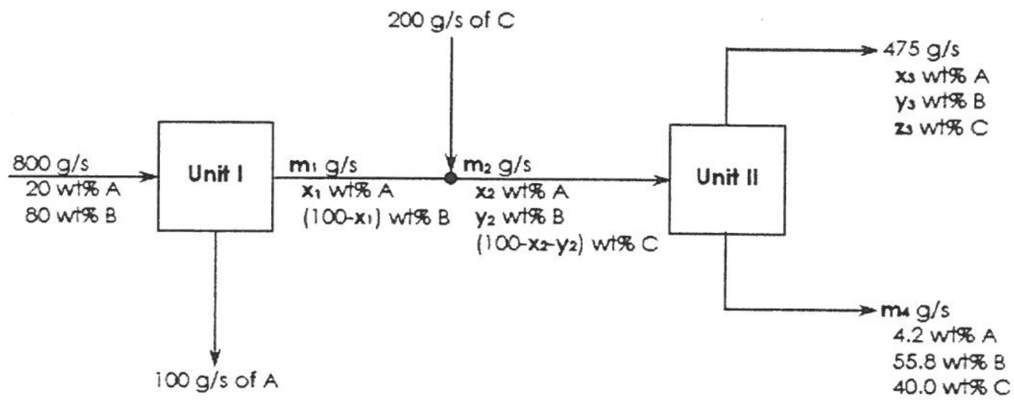

Diagram 3(b)/Rajah 3(b)

i) Calculate all unknowns flow rates **m_1, m_2 and m_4.**
*Kirakan semua kadar alir yang tidak diketahui **m_1, m_2 and m_4.***

[6 marks]
[6 *markah*]

ii) Calculate all the unknown compositions.
Kirakan semua komposisi yang tidak diketahui.

[6 marks]
[6 *markah*]

CLO2
C2

(b) Hydrogen is entering a fuel cell stack at a rate of 12.0. g/s and at a temperature and pressure of 40°C and 2.5 atm, respectively. Determine the volumetric flow rate of hydrogen in m^3/hr converting it from standard conditions. Molecular weight of H_2 is 2.0 g/mol.

Hidrogen telah memasuki 'fuel cell stack' dengan kadar 12.0 g/s, suhu dan tekanan masing-masing ialah 40°C dan 2.5 atm. Tentukan kadar alir isipadu hidrogen dalam m^3/jam dengan menukarkan daripada keadaan piawai. Berat molekul H_2 ialah 2.0 g/mol.

[9 marks]

[9 *markah*]

QUESTION 4

SOALAN 4

CLO1
C1

(a) Define the following terms:

i) Hess's Law
Hukum Hess

[2 marks]

[2 *markah*]

ii) Heat of formation
Haba pembentukan

[2 marks]

[2 *marka.*

CLO1
C3

(b) The constant-volume heat capacity of nitrous oxide N_2O at low pressures is given by the expression

$$C_v\ (kJ/kg.^{o}C) = 0.855 + 9.42 \times 10^{-4}T$$

Where T is in °C. A quantity of N_2O is kept in a piston-fitted cylinder with initial temperature, pressure and volume equal to 25 °C, 2.0 atm and 500.0 liters respectively. Molecular weight of N_2O is 44.0g/mol. Given: R=0.08206 liter.atm/mol.K . Calculate the heat (kJ) required to raise the gas temperature from 25 °C to 100° C if the heating takes place at constant volume.

Pemalar isipadu haba muatan N_2O pada tekanan rendah diberi dalam persamaan di bawah. Di mana Di mana T dalam °C . Sejumlah N_2O disimpan dalam 'piston-fitted cylinder' dengan suhu awal , tekanan awal dan isipadu awal masing-masing ialah 25 °C, 2.0 atm and 500.0 liters. Berat molekul N_2O ialah 44.0 g/mol. Diberi R=0.08206 liter.atm/mol. ***Kirakan*** *tenaga haba(kJ) yang diperlukan untuk menaikan suhu gas dari 25 °C to 100 °yang berlaku pada isipadu malar.*

[12 marks]
[12 markah]

CLO1
C3

(c) (i) Calculate ΔH(kJ) for the following reaction using the listed standard enthalpy of reaction data using Hess's law.

Kirakan ΔH(kJ) untuk tindak balas berikut dengan menggunakan senarai data 'standard enthalpy of reaction' menggunakan Hess's law.

$$C_2H_4(g) + 6\ F_2(g) \rightarrow 2\ CF_4(g) + 4\ HF(g)$$

Given:
Diberi:

$H_2(g) + F_2(g) \rightarrow 2\ HF(g)$ $\Delta H^o/kJ = -537$

$C(s) + 2\ F_2(g) \rightarrow CF_4(g)$ $\Delta H^o/kJ = -680$

$2\ C(s) + 2\ H_2(g) \rightarrow C_2H_4(g)$ $\Delta H^o/kJ = +52.3$

[5 marks]

[5 *markah*]

CLO2
C3

ii). Benzene C_6H_6 is an important hydrocarbon. The equation of the combustion of benzene $C_6H_6(l)$ is shown as below. Balance the equation and calculate the heat of reaction ΔH_{rxn} for this reaction.

Benzena C_6H_6 merupakan suatu hidrokarbon yang penting. Persamaan pembakaran benzena $C_6H_6(l)$ *ditunjukkan di bawah. Imbangkan persamac dan kirakan haba tindak balas bati tindak balas tersebut.*

$$C_6H_{6(l)} + O_{2(g)} \rightarrow CO_{2\,(g)} + H_2O_{(g)}$$

Given:

Diberi:

$\Delta H\ ^\circ f\,(C_6H_6) = +49.0$ kJ/mole.

$\Delta H\ ^\circ f\,(CO_2) = -393.5$ kJ/mole.

$\Delta H\ ^\circ f\,(H_2O) = -241.8$ kJ/mole.

$\Delta H\ ^\circ f\,(O_2) = 0$ kJ/mole.

[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. Kinetic Energy $= \frac{1}{2} mv^2$
4. Potential Energy $= mgh$

CHAPTER 2

1. $SG = \rho / \rho_{ref}$
2. $\rho_{ref}\ (H_2O, 4°C) = 1.000\ g/cm^3 = 1000\ kg/m^3 = 62.43\ lb_m/ft^3$
3. $\rho = m/V$
4. Avogadro's Number $= 6.02 \times 10^{23}$
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 3

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. $$\text{Overall conversion} = \frac{\text{reactant input to the process - reactant output from process}}{\text{reactant input to process}}$$
9. $$\text{Percentage excess air} = \frac{(\text{moles air})_{fed} - (\text{moles air})_{theoretical}}{(\text{moles air})_{theoretical}} \times 100\ \%$$
10. 100 % air ⟶ 79 % nitrogen and 21% oxygen

CHAPTER 4

1. Ideal gas law : PV = nRT : $\frac{PV}{P_s V_s} = \frac{nT}{n_s T_s}$: $\frac{P_1 V_1}{P_2 V_2} = \frac{T_1}{T_2}$

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

Pressure, P_s	Volume, V_s	Number of mol, n_s	Temperature, T_s
1 atm	0.022415 m^3	1 mol	273 K

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

CHAPTER 5

1. First Law of Thermodynamics for closed system:

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

2. Energy balance for closed system:

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

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

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