SULIT

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

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI II : 2021 / 2022

DGP30132 : MASS AND ENERGY BALANCE

TARIKH : 5 JULAI 2022
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **LAPAN (8)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Appendix 1 & 2

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

INSTRUCTION:

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

ARAHAN:

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

QUESTION 1

SOALAN 1

CLO1 C1

(a) Give **THREE (3)** examples of derived unit in terms of SI base unit.

*Berikan **TIGA (3)** contoh unit terbitan dalam sebutan unit asas SI.*

[3 marks]
[3 *markah*]

CLO1 C2

(b) i) Convert 5.75 m^3.Pa / mol.K to L.atm/mol.K

Tukarkan 5.75 m^3.Pa / mol.K kepada L.atm/mol.K

[4 marks]
[*4 markah*]

ii) Convert 2.5 g/cm^3 to Ib_m/gallon.

Tukarkan 2.5 g/cm^3 *kepada* Ib_m/gallon.

[5 marks]
[*5 markah*]

CLO1 C3

(c) i) Calculate the volume of a solution in cubic centimeter (cm^3) if the mass is 2.58 Ib_{mass} and density is 2.357x 10^{-3} g/mm^3.

Kirakan isipadu larutan dalam sentimeter padu (cm^3) jika jisim bahan ialah 2.58 Ib_{jisim} dan ketumpatan ialah 2.357x 10^{-3} g/mm^3.

[4 marks]
[*4 markah*]

ii) A 2.2 mol/liter solution of hydrochloric acid flows into a process unit at a rate of 12.45 m^3/min. Given the atomic weight of H= 1.01 g/mol and Cl=35.45 g/mol. Calculate mass concentration in kg/m^3 and mass flowrate in kg/s.

Satu larutan asid hidroklorik berkepekatan 2.2 mol/liter mengalir masuk ke dalam sebuah unit proses pada kadar 12.45 m^3/min. Diberi jisim atom untuk H= 1.01 g/mol dan Cl=35.45 g/mol. Kirakan kepekatan jisim kg/m^3 dan kadar alir jisim dalam kg/s.

[4 marks]
[4 markah]

iii) Convert the mass composition to molar composition of the following mixture by assuming basis as 100g [Atomic Weight N= 14.0 g/mol; Atomic Weight O = 16 g/mol]:
Tukarkan komposisi jisim kepada komposisi molar untuk campuran berikut dengan menganggap asas 100g. [Jisim atom N = 14.0 g/mol; Jisim atom O = 16 g/mol:

O_2 : 22 %
N_2 : 78%

[5 marks]
[5 markah]

QUESTION 2
SOALAN 2

CLO2
C1

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

i. Limiting reactant.
Bahan tindak balas terhad

ii. Theoretical oxygen.
Oksigen secara teori.

[4 marks]
[4 markah]

CLO2 C3

(b) Ammonia is burned to form nitric oxide and water.

The fractional conversion of oxygen is 0.6. The inlet molar flow rate is 6 mol/h of NH_3 and 5 mol/h of oxygen.

Ammonia dibakar untuk menghasilkan nitrus oksida dan air:

Pecahan penukaran oksigen ialah 0.6. Kadar alir molar masuk ammonia (NH_3) ialah 6 mol/hr dan oksigen ialah 5 mol/hr.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

i) Write the possible extent of reactions equations.

Tuliskan persamaan tindak balas had yang mungkin.

[4 marks]
[*4 markah*]

ii) Calculate the molar flowrates of all products.

Kirakan aliran molar semua produk.

[5 marks]
[5 *markah*]

CLO2 C3

(c) Acrylonitrile (C_3H_3N) is produced by the reaction of propylene, ammonia and oxygen. The feed contains 10.0 mol % propylene (C_3H_6), 12.0 mol % ammonia (NH_3) and 78 mol % air. A fractional conversion of 30 % of the limiting reactant is achieved. Taking 100 mol of feed as a basis, by using extent of reactant method:

Akrilonitril (C_3H_3N) dihasilkan melalui tindak balas propilena, ammonia dan oksigen. Suapan mengandungi 10.0 mol % propilena (C_3H_6), 12.0 mol % ammonia (NH_3) dan 78 mol % udara. Satu pecahan penukaran 30% daripada takat reaktan telah tercapai. Katakan 100 mol suapan adalah basis, dengan menggunakan kaedah takat reaktan:

$$C_3H_6 + NH_3 + \frac{3}{2}O_2 \rightarrow C_3H_3N + 3H_2O$$

i) Calculate the percentage of excess reactants.

Kirakan peratus bahan-bahan tindak balas yang berlebihan.

[5 marks]
[5 *markah*]

ii) Calculate the molar amounts of all gas products.
Kirakan jumlah molar untuk kesemua hasil gas.

[7 marks]
[7 *markah*]

QUESTION 3
SOALAN 3

CLO1 C1

(a) Give **TWO (2)** factors affecting the density.
*Berikan **DUA (2)** faktor yang mempengaruhi ketumpatan.*

[4 marks]
[*4 markah*]

CLO1 C2

(b) The pressure gauge on a 45.0 m^3 tank of nitrogen at 25°C reads 10 bar. Approximate the mass of nitrogen in the tank by:

Tekanan tolok di dalam sebuah 45.0 m^3 tangki nitrogen pada 25 °C memberikan bacaan 10 bar. Anggarkan berat nitrogen di dalam tangki dengan:

i) Using direct solution of the ideal gas equation of state.
Menggunakan penyelesaian terus dari persamaan gas unggul.

[4 marks]
[*4 markah*]

ii) Using conversion from standard conditions.
Menggunakan penukaran dari keadaan-keadaan piawai.

[4 marks]
[*4 markah*]

CLO1 C3

(c) i) A well-insulated tank has a volume of 2m^3 and initially filled with 200g Helium (He). After a while, the tank is filled up with 70g oxygen until it is full. Calculate the partial pressure of each gas at 15°C after it is fully filled up, and calculate the total pressure in the tank at this temperature. [Atomic weight He = 4 g/mol]

Sebuah tangki mempunyai isipadu 2m³ dan diisi dengan 200g Helium (He). Selepas seketika, tangki diisi dengan 70g oksigen sehingga penuh. Kirakan tekanan separa untuk setiap gas pada 15°C selepas ia diisi hingga penuh, dan kirakan jumlah tekanan di dalam tangki pada suhu tersebut.[Jisim atom He = 4g/mol].

[6 marks]
[6 markah]

ii) Ethane (C_2H_6) enters a fuel cell stack at a rate of 750g/hr and at a temperature and pressure of 34°C and 10 bar respectively. Calculate the volumetric flow rate of oxygen in m^3/hr converting it from standard condition.

Oksigen memasuki 'fuel cell stack' dengan kadar 650g/jam masing-masing pada suhu dan tekanan 24°C dan 10 bar. Kirakan kadar alir isipadu oksigen dalam m^3/jam dengan tukaran keaadaan piawai.

[7 marks]
[7 markah]

QUESTION 4
SOALAN 4

CLO2 C1 (a) Define the kinetic energy by giving its formula.
Takrifkan tenaga kinetik dengan menyatakan rumusnya.

[4 marks]
[4 markah]

CLO2 C2 (b)

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

The feed to a reactor contains 40 kmol C_2H_4 and 40 kmol O_2.
Bahan masuk ke reaktor mengandungi 40 kmol C_2H_4 and 40 kmol O_2.

i) Categorise the limiting reactant and excess reactant.
Kategorikan yang mana adalah bahan pengehad.

[4 marks]
[4 markah]

ii) Approximate the percentage excess of the other reactant.
Anggarkan peratus lebihan bahan tindak balas yang lain.

[4 marks]
[*4 markah*]

CLO2
C3

(c) Based on the situation given:
Berdasarkan situasi yang diberikan:

i) The specific internal energy of helium at 25°C and 1 atm is 4.80 kJ/mol, and the specific molar volume under the same conditions is 25 L/mol. Calculate the specific enthalpy of helium at this temperature and pressure, and the rate at which enthalpy is transported by a stream with a molar flow rate of 250 kmol/h.
Tenaga dalaman tentu helium pada 25°C dan 1 atm ialah 4.80 kJ/mol, dan isipadu molar tentu dalam keadaan yang sama ialah 25 L/mol. Kira entalpi tentu bagi helium pada suhu dan tekanan ini. dan kadar di mana entalpi diangkut oleh aliran dengan kadar alir molar 250 kmol/j.

[4 marks]
[*4 markah*]

ii) The internal energy of reaction at standard condition (25°C, 1 atm) is -500 kJ/mol. Calculate the standard heat of reaction of the following reaction:
Tenaga dalaman tindak balas pada keadaan piawai (25°C, 1 atm) ialah -500 kJ/mol. Kira haba piawaian tindak balas bagi tindak balas berikut:

$$C_2H_4\,(g) + 2Cl_2\,(g) \rightarrow C_2HCl_3\,(l) + H_2 + HCl\,(g)$$

[5 marks]
[*5 markah*]

iii) Calculate the heat of combustion for C_2H_6 from the following reactions:

Kira haba pembakaran untuk C_2H_6 daripada tindak balas berikut:

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ΔH_{r1} = -1410.5 kJ/mol

$C_2H_4 + H_2 \rightarrow C_2H_6$ ΔH_{r2} = -140.7 kJ/mol

$H_2 + 1/2O_2 \rightarrow H_2O$ ΔH_{r3} = -285.5 kJ/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 II

FORMULAS & EQUATIONS

CHAPTER 1

1. $W = mg$
2. $g = 9.8066 \text{ m/s}^2 = 980.66 \text{ cm/s}^2 = 32.174 \text{ ft/s}^2$
3. $SG = \rho / \rho_{ref}$
2. $\rho_{ref}\,(H_2O, 4^\circ C) = 1.000 \text{ g/cm}^3 = 1000 \text{ kg/m}^3 = 62.43 \text{ lb}_m/\text{ft}^3$
3. Density, $\rho = \frac{m}{V}$
4. Avogadro's Number = 6.02×10^{23}
5. $Number\ of\ mole, n = \frac{mass}{Molecular\ weight}$
6. $Mass\ Fraction, x = \frac{m}{m_{Total}}$ 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 = $\frac{(\text{moles air})_{fed} - (\text{moles air})_{theoretical}}{(\text{moles air})_{theoretical}} \times 100\ \%$

9 100 mol air ⟶ 79 mol% nitrogen

⟶ 21 mol% oxygen

CHAPTER 3

1. Ideal gas law : PV = nRT

$$\frac{PV}{P_s V_s} = \frac{nT}{n_s T_s} \quad : \quad \frac{P_1 V_1}{P_2 V_2} = \frac{T_1}{T_2}$$

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

System	T_s	P_s	V_s	n_s
S.I	273K	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 $\Delta H = \sum n\,\Delta H_{(products)} - \sum n \Delta H_{(reactants)}$