

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**

- (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
C1

- (b) i) Convert $5.75 \text{ m}^3 \cdot \text{Pa} / \text{mol.K}$ to L.atm/mol.K

Tukarkan $5.75 \text{ m}^3 \cdot \text{Pa} / \text{mol.K}$ kepada L.atm/mol.K .

[4 marks]
[4 markah]

CLO1
C2

- ii) Convert 2.5 g/cm^3 to $\text{lb}_m/\text{gallon}$.

Tukarkan 2.5 g/cm^3 kepada $\text{lb}_m/\text{gallon}$.

[5 marks]
[5 markah]

CLO1
C3

- (c) i) Calculate the volume of a solution in cubic centimeter (cm^3) if the mass is $2.58 \text{ lb}_{\text{mass}}$ and density is $2.357 \times 10^{-3} \text{ g/mm}^3$.

Kirakan isipadu larutan dalam sentimeter padu (cm^3) jika jisim bahan ialah $2.58 \text{ lb}_{\text{jisim}}$ dan ketumpatan ialah $2.357 \times 10^{-3} \text{ g/mm}^3$.

[4 marks]
[4 markah]

- ii) A 2.2 mol/liter solution of hydrochloric acid flows into a process unit at a rate of $12.45 \text{ m}^3/\text{min}$. 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 $12.45 \text{ m}^3/\text{min}$. Diberi jisim atom untuk $H = 1.01 \text{ g/mol}$ dan $Cl = 35.45 \text{ g/mol}$. 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.

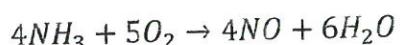
Oksigen secara teori.

[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 NH₃ 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 (NH₃) ialah 6 mol/hr dan oksigen ialah 5 mol/hr.



- i) Write the possible extent of reactions equations.

Tuliskan persamaan tindak balas had yang mungkin.

[4 marks]
[4 markah]

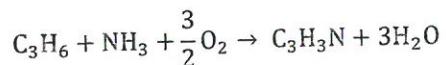
- ii) Calculate the molar flowrates of all products.

Kirakan aliran molar semua produk.

[5 marks]
[5 markah]

- CLO2 C3 (c) Acrylonitrile (C₃H₃N) is produced by the reaction of propylene, ammonia and oxygen. The feed contains 10.0 mol % propylene (C₃H₆), 12.0 mol % ammonia (NH₃) 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 (C₃H₃N) dihasilkan melalui tindak balas propilena, ammonia dan oksigen. Suapan mengandungi 10.0 mol % propilena (C₃H₆), 12.0 mol % ammonia (NH₃) dan 78 mol % udara. Satu pecahan penukaran 30% daripada takat reaktan telah tercapai. Katakan 100 mol suapan adalah basis, dengan menggunakan kaedah takat reaktan:



- 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 tolak 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 2m^3 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 $\text{He} = 4\text{g/mol}$.]

[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 keadaan 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



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:

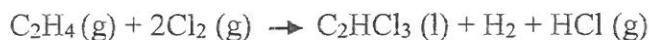
- i) The specific internal energy of helium at 25°C and 1 atm is 4.80 kJ/mol, and the specific molar volume under the same conditions is 25 L/mol. Calculate the specific enthalpy of helium at this temperature and pressure, and the rate at which enthalpy is transported by a stream with a molar flow rate 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:

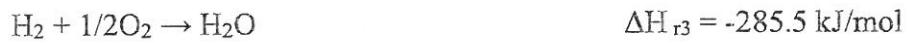
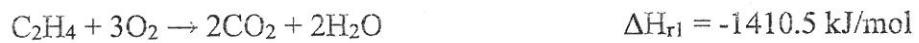
Tenaga dalaman tindak balas pada keadaan piawai (25°C, 1 atm) ialah -500 kJ/mol. Kira haba piawaian tindak balas bagi tindak balas berikut:



[5 marks]
[5 markah]

- iii) Calculate the heat of combustion for C₂H₆ from the following reactions:

Kira haba pembakaran untuk C₂H₆ daripada tindak balas berikut:



[4 marks]
[4 markah]

SOALAN TAMAT

Appendix 1

Table of Unit Conversions

Quantity	Equivalent Values
Mass	$1 \text{ kg} = 1000 \text{ g} = 0.001 \text{ metric ton} = 2.20462 \text{ lb}_m = 35.27392 \text{ oz}$ $1 \text{ lb}_m = 16 \text{ oz} = 5 \times 10^{-4} \text{ ton} = 453.593 \text{ g} = 0.453593 \text{ kg}$
Length	$1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 10^6 \text{ microns } (\mu\text{m}) = 10^{10} \text{ angstroms } (\text{\AA})$ $= 39.37 \text{ in.} = 3.2808 \text{ ft} = 1.0936 \text{ yd} = 0.0006214 \text{ mile}$
Volume	$1 \text{ m}^3 = 1000 \text{ liters} = 10^6 \text{ cm}^3 = 10^6 \text{ ml}$ $= 35.3145 \text{ ft}^3 = 220.83 \text{ imperial gallons} = 264.17 \text{ gal}$ $= 1056.68 \text{ qt}$ $1 \text{ ft}^3 = 1728 \text{ in}^3 = 7.4805 \text{ gal} = 0.028317 \text{ m}^3 = 28.317 \text{ liters}$ $= 28.317 \text{ cm}^3$
Force	$1 \text{ N} = 1 \text{ kg.m/s}^2 = 10^5 \text{ dynes} = 10^5 \text{ g.cm/s}^2 = 0.22481 \text{ lb}_f$ $1 \text{ lb}_f = 32.174 \text{ lbm.ft/s}^2 = 4.4482 \text{ N} = 4.4482 \times 10^4 \text{ dynes}$
Pressure	$1 \text{ atm} = 1.01325 \times 10^5 \text{ N/m}^2 (\text{Pa}) = 101.325 \text{ kPa} = 1.01325 \text{ bars}$ $= 1.01325 \times 10^6 \text{ dynes/cm}^2$ $= 760 \text{ mm Hg at } 0^\circ\text{C (torr)} = 10.333 \text{ m H}_2\text{O at } 4^\circ\text{C}$ $= 14.696 \text{ lb}_f/\text{in}^2 (\text{psi}) = 33.9 \text{ ft H}_2\text{O at } 4^\circ\text{C}$ $= 29.921 \text{ in Hg at } 0^\circ\text{C}$
Energy	$1 \text{ J} = 1 \text{ N.m} = 10^7 \text{ ergs} = 10^7 \text{ dyne.cm}$ $= 2.778 \times 10^{-7} \text{ kW.h} = 0.23901 \text{ cal}$ $= 0.7376 \text{ ft-lb}_f = 9.486 \times 10^{-4} \text{ Btu}$
Power	$1 \text{ W} = 1 \text{ J/s} = 0.23901 \text{ cal/s} = 0.7376 \text{ ft.lb}_f/\text{s} = 9.468 \times 10^{-4} \text{ Btu/s}$ $= 1.341 \times 10^{-3} \text{ hp}$

Appendix IIFORMULAS & EQUATIONSCHAPTER 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. $\rho_{ref} (\text{H}_2\text{O}, 4^\circ\text{C}) = 1.000 \text{ g/cm}^3 = 1000 \text{ kg/m}^3 = 62.43 \text{ lb}_m/\text{ft}^3$
3. Density, $\rho = \frac{m}{V}$
4. Avogadro's Number = 6.02×10^{23}
5. $\text{Number of mole, } n = \frac{\text{mass}}{\text{Molecular weight}}$
6. $\text{Mass Fraction, } x = \frac{m}{m_{Total}} \quad \text{and} \quad \text{Mole Fraction, } y = \frac{n}{n_{total}}$

CHAPTER 2

1. General Balance Equation for steady state process:
input + generation = output + consumption
2. $\text{Fractional excess} = \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}}$
3. $\text{percentage excess} = \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}} \times 100\%$
4. $\text{fractional conversion, } f = \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}}$
5. $\% \text{ fractional conversion} = \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}} \times 100\%$
6. $\text{Yield} = \frac{\text{moles}_{(\text{desired product})}}{\text{moles}_{(LR)}} \times \frac{\text{stoichiometry coefficient}_{(LR)}}{\text{stoichiometry coefficient}_{(DP)}} \times 100\%$

7 $>Selectivity = \frac{moles_{(desired\ product)}}{moles_{(undesired\ product)}}$

8 Percentage excess air = $\frac{(moles\ air)_{fed} - (moles\ air)_{theoretical}}{(moles\ air)_{theoretical}} \times 100\%$

9 100 mol air \longrightarrow 79 mol% nitrogen
 \longrightarrow 21 mol% oxygen

CHAPTER 3

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, $R = 8.314 \text{ m}^3.\text{Pa/mol.K} = 0.08314 \text{ liter.bar/mol.K} = 0.08206 \text{ liter.atm/mol.K} = 63.36 \text{ liter.mm Hg/mol.K} = 0.7302 \text{ ft}^3.\text{atm/lb-mole.}^\circ\text{R} = 10.73 \text{ ft}^3.\text{psia/lb-mole.}^\circ\text{R} = 8.314 \text{ J/mol.K} = 1.987 \text{ cal/mol.K} = 1.987 \text{ Btu/lb-mole.}^\circ\text{R}$

4. $T(\text{K}) = T(\text{ }^\circ\text{C}) + 273$

$T(\text{ }^\circ\text{R}) = T(\text{ }^\circ\text{F}) + 460$

$T(\text{ }^\circ\text{F}) = T(\text{ }^\circ\text{C}) \frac{5}{9} + 32$

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. $V_s/ns = 0.0224 \text{ m}^3 \text{ (STP)/mol} = 22.4 \text{ liters(STP)/mol} = 359 \text{ ft}^3\text{(STP)/lb-mole}$

CHAPTER 4

1. Kinetic Energy $= \frac{1}{2} mv^2$
2. Potential Energy $= mgh$
3. First Law of Thermodynamics for closed system:

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

4. Energy balance for closed system:

$$Q = \Delta U = m \Delta \hat{U}$$

5. Specific internal energy, $\Delta \hat{U} = \int_{T_1}^{T_2} Cv(T) dT$
6. Heat of reaction $\Delta H = \sum n \Delta H_{(\text{products})} - \sum n \Delta H_{(\text{reactants})}$