



**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 : 2025/2026**

**DGP30373 : MASS AND ENERGY BALANCE**

**TARIKH : 27 NOVEMBER 2025**

**MASA : 2.30 PETANG – 4.30 PETANG (2 JAM)**

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Kertas soalan ini mengandungi **EMPAT BELAS (14)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula

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**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) Basic concept measurement and derived concept measurement are fundamentally used in the engineering calculation. State the concept type measurement for volume with the International System of Units (SI unit).

*Konsep pengukuran asas dan konsep pengukuran terbitan digunakan secara asasnya dalam pengiraan kejuruteraan. Nyatakan jenis konsep pengukuran untuk isipadu dengan Sistem Unit Antarabangsa (unit SI).*

[2 marks]

[2 markah]

CLO1

- (b) Conversion factor is defined as a ratio of equivalent values of a quantity expressed in different units. Convert:

*Faktor penukaran ditakrifkan sebagai nisbah nilai setara suatu kuantiti yang dinyatakan dalam unit yang berbeza. Tukarkan:*

- (i) an acceleration of  $0.52 \text{ km/yr}^2$  to its equivalent in  $\text{cm/s}^2$ .

*satu pecutan bagi  $0.52 \text{ km/yr}^2$  kepada nilai yang sama dalam  $\text{cm/s}^2$ .*

[5 marks]

[5 markah]

- (ii) a force of  $0.167 \text{ kg.cm/s}^2$  to its equivalent in  $\text{lb}_m.\text{ft/min}^2$ .

*satu daya bagi  $0.167 \text{ kg.cm/s}^2$  kepada nilai yang sama dalam  $\text{lb}_m.\text{ft/min}^2$ .*

[5 marks]

[5 markah]

CLO1

- (c) A 0.25 mol/liter solution of HCl (hydrochloric acid) flows into a process unit at a rate of 0.35 m<sup>3</sup>/min. The specific gravity of the solution is 1.18. Molecular weight of HCl is 36.46. Calculate:

*Satu larutan HCl (asid hidroklorik) 0.25 mol/liter mengalir ke dalam satu unit proses pada kadar 0.35 m<sup>3</sup>/min. Graviti tentu bagi larutan tersebut adalah 1.18. Berat molekul HCl ialah 36.46. Kirakan:*

- i) the mass concentration of HCl in kg/m<sup>3</sup>.

*kepekatan jisim HCl dalam kg/m<sup>3</sup>.*

[4 marks]

[4 markah]

- ii) the mass flow rate of HCl in kg/s.

*kadar alir jisim HCl dalam kg/s.*

[4 marks]

[4 markah]

- iii) the mass fraction of HCl.

*pecahan jisim bagi HCl.*

[5 marks]

[5 markah]

**QUESTION 2****SOALAN 2**

CLO1

(a) State **TWO (2)** characteristics of  
*Nyatakan DUA (2) ciri-ciri bagi*

i) batch process  
*proses berkelompok*

[2 marks]

[2 markah]

ii) continuous process.  
*proses berterusan.*

[2 marks]

[2 markah]

CLO1

(b) A 2500 kg/h ethanol-methanol stream to be separated in a distillation column is shown in Figure 2(b) below. The feed stream contains 45% ethanol and the distillate contains 60% methanol. The flow of the bottom product is 1200 kg/h. Calculate:

*Satu aliran etanol-metanol 2500 kg/j dipisahkan dalam turus penyulingan seperti yang ditunjukkan pada Rajah 2(b) di bawah. Aliran suapan mengandungi 45% etanol dan sulingan tersebut mengandungi 60% metanol. Aliran di bahagian bawah produk ialah 1200 kg/j. Kirakan:*

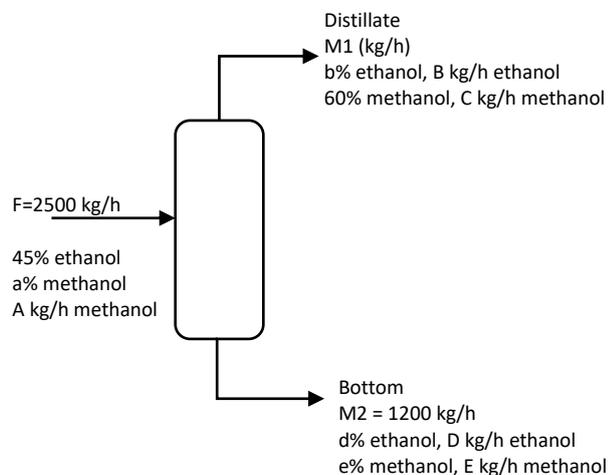


Figure 2(b)/Rajah 2 (b)

- a) all unknown stream composition and flow rates for methanol.  
*semua komposisi aliran dan kadar aliran yang tidak diketahui bagi metanol.*

[4 marks]

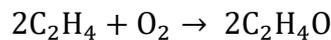
[4 markah]

- b) all unknown stream composition and flow rates for ethanol.  
*semua komposisi aliran dan kadar aliran yang tidak diketahui bagi etanol.*

[5 marks]

[5 markah]

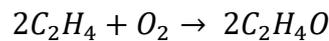
- c) Ethylene oxide ( $C_2H_4O$ ) is produced by the reaction of ethylene ( $C_2H_4$ ) with oxygen as below:



The feed to the reactor contains 15 mol/h of ethylene and 10 mol/h of oxygen.

Calculate:

*Etilena oksida ( $C_2H_4O$ ) dihasilkan dengan tindak balas etilena ( $C_2H_4$ ) dengan oksigen seperti dibawah:*



*Suapan ke dalam reaktor mengandungi 15 mol/j etilena, dan 10 mol/j oksigen. Kirakan:*

- i) the percentage reactant in excess.  
*peratus reaktan yang berlebihan.*

[6 marks]

[6 markah]

- ii) the molar amounts of all gas products using extent of reaction method when fractional conversion of limiting reactant 65% is achieved.  
*kadar mol untuk kesemua hasil gas menggunakan kaedah tindak balas takat apabila pecahan penukaran bagi reaktan terhad ialah 65% dicapai.*

[6 marks]

[6 markah]

CLO1

**QUESTION 3****SOALAN 3**

CLO1

- (a) i) Define partial pressure for mol A in a gas mixture.  
*Definisikan tekanan separa bagi mol A dalam satu campuran gas.*
- [2 marks]  
[2 markah]
- ii) State **TWO (2)** factors that affect the density.  
*Nyatakan DUA (2) faktor yang mempengaruhi ketumpatan.*
- [2 marks]  
[2 markah]

CLO1

- (b) Carbon dioxide is available under the following condition with 230g of mass, a pressure of 250kPa, temperature at 32°C and molecular weight of 44g/mol. Assuming that it has ideal gas behavior. Approximate:  
*Karbon dioksida diperolehi di bawah keadaan berikut dengan jisim 230g, pada tekanan 250kPa, berada pada suhu 32°C dan mempunyai berat molekul 44g/mol. Andaikan gas tersebut bersifat unggul. Anggarkan:*
- i) the volume in  $m^3$  by using conversion from standard conditions.  
*isipadu gas ini dalam  $m^3$  dengan menggunakan penukaran daripada keadaan piawai.*
- [4 marks]  
[4 markah]
- ii) the gas constant in  $m^3 \cdot Pa/mole \cdot K$ .  
*nilai pemalar gas dalam  $m^3 \cdot Pa/mol \cdot K$ .*
- [4 marks]  
[4 markah]

CLO1

(c)

- i) A gaseous mixture made from 23 g O<sub>2</sub> and 37 g CH<sub>4</sub> is placed in a 50 L vessel at 40°C. Calculate the partial pressure of each gas and the total pressure in the tank.

*Campuran gas yang dibuat daripada 23 g O<sub>2</sub> dan 37 g CH<sub>4</sub> diletakkan dalam vesel 50 L pada suhu 40°C. Kirakan tekanan separa setiap gas dan jumlah tekanan dalam tangki.*

[6 marks]

[6 markah]

- ii) Oxygen gas is collected in a pneumatic trough with a volume of 0.55 m<sup>3</sup> at the atmospheric pressure of 748 torr, and the temperature is 300 K until the height of the water inside the trough is equal to the height of the water outside the trough. The vapor pressure of water is 21.4 torr at 300 K. Calculate the moles of oxygen present in the trough.

*Gas oksigen dikumpulkan di dalam palung pneumatik dengan isipadu 0.55 m<sup>3</sup> pada tekanan atmosfera adalah 748 torr dan suhu 300 K sehingga paras air di dalam palung sama dengan ketinggian air di luar palung. Tekanan wap air ialah 21.4 torr pada 300K. Kirakan bilangan mol oksigen yang hadir di dalam palung tersebut.*

[7 marks]

[7 markah]

**QUESTION 4****SOALAN 4**

CLO1

- (a) In a closed system, energy may be transferred between such system and its surrounding in two ways as heat or work. Describe:

*Dalam satu sistem tertutup, tenaga boleh dipindahkan antara sistem dan persekitarannya dalam dua arah iaitu sebagai haba atau kerja. Terangkan:*

- i) heat ( $Q$ ) that occurs within the system.  
*haba ( $Q$ ) yang wujud di antara sistem tersebut.*

[2 marks]

[2 markah]

- ii) work ( $W$ ) that occurs within the system.  
*kerja ( $W$ ) yang wujud antara sistem tersebut.*

[2 marks]

[2 markah]



CLO1

The feed to a reactor contains 150kmol  $\text{C}_2\text{H}_4$  and 130kmol  $\text{O}_2$ . Based on the above reaction, calculate:

*Suapan masuk ke reaktor mengandungi 150kmol  $\text{C}_2\text{H}_4$  and 130kmol  $\text{O}_2$ .*

*Berdasarkan tindak balas di atas, kirakan:*

- i) the limiting reactant.  
*bahan pengehad.*

[4 marks]

[4 markah]

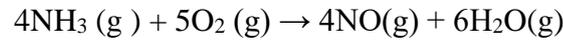
- ii) the percentage excess of the other reactant.  
*peratus lebihan bahan tindak balas yang lain.*

[4 marks]

[4 markah]

CLO1

(c) Based on the situation given:

*Berdasarkan situasi yang diberikan:*i) Calculate the  $\Delta H_{rxn}$  for the following reaction:*Kirakan  $\Delta H_{rxn}$  untuk tindak balas berikut:*Given the following  $\Delta H$  at 25°C.*Diberi  $\Delta H$  pada 25°C.*NH<sub>3</sub> (g): -50.251 kJ/ mol

NO(g): +85.253 kJ/mol

H<sub>2</sub>O (g): -187.065 kJ/mol

[4 marks]

[4 markah]

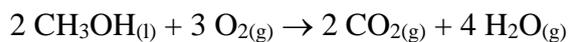
ii) Water is pumped at a rate of 25 kg/s from a point of 150 m below the earth surface to a point of 20 m above the ground level. Calculate the rate of change in potential energy,  $E_P$  in kW.

*Air dipam pada kadar 25 kg/s dari titik 150 m di bawah permukaan bumi ke titik 20 m di atas paras tanah. Kirakan perubahan tenaga keupayaan,  $E_P$  yang terhasil dalam proses ini dalam kW.*

[5 marks]

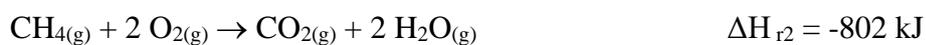
[5 markah]

- iii) Calculate the standard heat of reaction ( $\Delta H_r$ ) using the Hess' Law for:  
*Kirakan haba piawai tindak balas ( $\Delta H_r$ ) menggunakan Hess' Law bagi:*



The standard heat of the following combustion reactions has been determined experimentally:

*Haba piawai untuk tindak balas pembakaran berikut telah ditentukan secara ujikaji:*



[4 marks]

[4 markah]

**SOALAN TAMAT**

Table 1 Unit Conversions

Quantity	Equivalent Values
<b>Mass</b>	1 kg = 1000 g = 0.001 metric ton = 2.20462 lb <sub>m</sub> = 35.27392 oz 1 lb <sub>m</sub> = 16 oz = 5 X 10 <sup>-4</sup> ton = 453.593 g = 0.453593 kg
<b>Length</b>	1 m = 100 cm = 1000 mm = 10 <sup>6</sup> microns ( $\mu m$ ) = 10 <sup>10</sup> angstroms (A) = 39.37 in. = 3.2808 ft = 1.0936 yd = 0.0006214 mile
<b>Volume</b>	1 m <sup>3</sup> = 1000 liters = 10 <sup>6</sup> cm <sup>3</sup> = 10 <sup>6</sup> ml = 35.3145 ft <sup>3</sup> = 220.83 imperial gallons = 264.17 gal = 1056.68 qt 1 ft <sup>3</sup> = 1728 in <sup>3</sup> = 7.4805 gal = 0.028317 m <sup>3</sup> = 28.317 liters = 28 317 cm <sup>3</sup>
<b>Force</b>	1 N = 1 kg.m/s <sup>2</sup> = 10 <sup>5</sup> dynes = 10 <sup>5</sup> g.cm/s <sup>2</sup> = 0.22481 lb <sub>f</sub> 1 lb <sub>f</sub> = 32.174 lbm.ft/s <sup>2</sup> = 4.4482 N = 4.4482 X 10 <sup>4</sup> dynes
<b>Pressure</b>	1 atm = 1.01325 x 10 <sup>5</sup> N/m <sup>2</sup> (Pa) = 101.325 kPa = 1.01325 bars = 1.01325 x 10 <sup>6</sup> dynes/cm <sup>2</sup> = 760 mm Hg at 0 °C (torr) = 10.333 m H <sub>2</sub> O at 4 °C = 14.696lb <sub>f</sub> /in <sup>2</sup> (psi) = 33.9 ft H <sub>2</sub> O at 4 °C = 29.921 in Hg at 0 °C
<b>Energy</b>	1 J = 1 N.m = 10 <sup>7</sup> ergs = 10 <sup>7</sup> dyne.cm = 2.778 x 10 <sup>-7</sup> kW.h = 0.23901 cal = 0.7376 ft-lb <sub>f</sub> = 9.486 x 10 <sup>-4</sup> Btu
<b>Power</b>	1 W = 1J/s = 0.23901 cal/s = 0.7376 ft.lb <sub>f</sub> /s = 9.468 x 10 <sup>-4</sup> Btu/s = 1.341 x 10 <sup>-3</sup> hp

FORMULAS & 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. *Specific Gravity, SG*  $= \frac{\rho}{\rho_{ref}}$
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,  $\rho$*   $= \frac{m}{v} = \frac{\dot{m}}{\dot{v}}$
4. Avogadro's Number  $= 6.02 \times 10^{23}$
5. *number of moles*  $= \frac{\text{mass}}{\text{Molecular weight}}$  OR  $n = \frac{m}{M_r}$  or  $\dot{n} = \frac{\dot{m}}{M_r}$
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:  

$$\text{input} + \text{generation} = \text{output} + \text{consumption}$$
2. *Fractional excess*  $= \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}}$
3. *percentage excess*  $= \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}} \times 100\%$
4. *fractional conversion,  $f$*   $= \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}}$
5. *% fractional conversion*  $= \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}} \times 100\%$

$$6. \quad \text{Yield} = \frac{\text{moles}_{(\text{desired product})}}{\text{moles}_{(\text{LR})}} \times \frac{\text{stoichiometry coefficient}_{(\text{LR})}}{\text{stoichiometry coefficient}_{(\text{DP})}} \times 100\%$$

$$7. \quad \text{Selectivity} = \frac{\text{moles}_{(\text{desired product})}}{\text{moles}_{(\text{undesired product})}}$$

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

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

### CHAPTER 3

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

$$2. \quad P_{\text{absolute}} = P_{\text{atmospheric}} + P_{\text{gauge}}$$

$$3. \quad \text{Gas constant, } R = 8.314 \text{ m}^3 \cdot \text{Pa} / \text{mol} \cdot \text{K} = 0.08314 \text{ liter} \cdot \text{bar} / \text{mol} \cdot \text{K} = 0.08206 \text{ liter} \cdot \text{atm} / \text{mol} \cdot \text{K}$$

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

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

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

5. Standard Condition for gases

System	T <sub>s</sub>	P <sub>s</sub>	V <sub>s</sub>	n <sub>s</sub>
SI	273 K	1 atm	0.022415 m <sup>3</sup>	1 mol

$$6. \quad V_s/n_s = 0.0224 \text{ m}^3 \text{ (STP)/mol} = 22.4 \text{ liters(STP)}$$

**CHAPTER 4**

1. Kinetic Energy =  $\frac{1}{2} m v^2$

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:

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

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

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