

**STRUCTURED QUESTIONS: 100 MARKS****SOALAN STRUKTUR: 100 MARKAH****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 | <p>(a) Define mass.<br/><i>Takrifkan jisim.</i></p> <p style="text-align: right;">[3 marks]<br/>[3 markah]</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| CLO1 | <p>(b) Given that the density of water at 4°C is 1 g/cm<sup>3</sup>. Approximate the mass of the following in g.<br/><i>Diberi bahawa ketumpatan air pada 4°C ialah 1 g/cm<sup>3</sup>. Anggarkan jisim berikut dalam g.</i></p> <p>i) Substance A has a specific gravity of 1.5189 and the volume is 8 ft<sup>3</sup>.<br/><i>Bahan A mempunyai graviti tentu 1.5189 dan isipadunya ialah 8 ft<sup>3</sup>.</i></p> <p style="text-align: right;">[4 marks]<br/>[4 markah]</p> <p>ii) 50 gallons of acetic acid and the specific gravity of acetic acid is 1.022.<br/><i>50 gelen asid asetik dan graviti tentu asid asetik ialah 1.022.</i></p> <p style="text-align: right;">[5 marks]<br/>[5 markah]</p> |

CLO1

(c) Calculate the following item which contains 5.38 kg of carbon dioxide,  $\text{CO}_2$ .

Given: Atomic Weight of C is 12 g/mol and O is 16 g/mol.

*Kirakan item berikut yang mengandungi 5.38 kg karbon dioksida,  $\text{CO}_2$*

*Diberi: Berat Atom C ialah 12 g/mol dan O ialah 16 g/mol.*

i) the number of moles of carbon dioxide,  $\text{CO}_2$ .

*bilangan mol karbon dioksida,  $\text{CO}_2$ .*

[4 marks]

[4 markah]

ii) the number mol of C.

*bilangan mol atom C*

[4 marks]

[4 markah]

iii) the mass of O.

*bilangan jisim bagi O.*

[5 marks]

[5 markah]

## QUESTION 2

## SOALAN 2

CLO2

- (a) In a continuous process, the inputs and outputs flow continuously throughout the duration of the process.

*Dalam proses berterusan, input dan output mengalir secara berterusan sepanjang tempoh proses.*

- i) State the balance equation on a non-reactive species or on total mass.  
*Nyatakan persamaanimbangan pada spesies tidak reaktif atau pada jumlah jisim.*

[2 marks]

[2 markah]

- ii) Define “accumulation” term.  
*Takrifkan istilah pengumpulan.*

[2 marks]

[2 markah]

CLO2

- (b) The feed mixture with a mass flow rate of 1500 kg/h containing 40% benzene (B) and 60% toluene (T) by mass is fed to a distillation column. The overhead stream contains 90% B and the bottom product contains 10% of the benzene fed to the column.

*Campuran suapan dengan kadar aliran jisim 1500 kg/j yang mengandungi 40% benzena (B) dan 60% toluena (T) mengikut jisim disuap ke ruang penyulingan. Aliran overhead mengandungi 90% B dan produk bawah mengandungi 10% benzena yang disalurkan ke lajur.*

- i) Draw a labeled flow diagram of the system.  
*Lukiskan carta alir berlabel sistem*

[3 marks]

[3 markah]

- ii) Calculate the overhead product mass flow rate and the flow rate and mass fractions of the bottom product stream.  
*Kirakan kadar aliran jisim hasil overhed dan kadar aliran dan pecahan jisim aliran hasil bawah.*
- [6 marks]  
[6 markah]
- CLO2 (c) 50 mol/s of Nitrogen, 150 mol/s of Hydrogen and 1 mol/s Argon are fed into a reactor which proceeds with the following reaction. the fractional conversion of Hydrogen is 0.7  
*50 mol/s Nitrogen, 150 mol/s Hidrogen dan 1 mol/s Argon dimasukkan ke dalam reaktor yang meneruskan tindak balas berikut. Penukaran pecahan Hidrogen ialah 0.7.*
- $$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$$
- i) Calculate the extent of reaction.  
*Kirakan takat tindak balas*
- [6 marks]  
[6 markah]
- ii) Calculate the outlet composition of each species as it exits the reactor.  
*Kirakan komposisi alur keluar setiap spesies apabila ia keluar dari reactor*
- [6 marks]  
[6 markah]

## QUESTION 3

## SOALAN 3

CLO1

(a) Define the following items:

*Takrifkan perkara berikut:*i) Partial Pressure,  $P_A$ .*Tekanan Separa,  $P_A$ .*

[2 marks]

[2 markah]

ii) Pure Component Volume,  $V_A$ .*Isipadu Komponen Tulen,  $V_A$ .*

[2 marks]

[2 markah]

CLO1

(b) An ideal gas at 30°C and a pressure of 2.0 atm occupies a volume of 150 ml.

*Gas ideal pada 30°C dan tekanan 2.0 atm menempati isipadu 150 ml.*

i) Approximate the moles of a gas present.

*Anggarkan bilangan mol gas yang ada.*

[4 marks]

[4 markah]

ii) Approximate the volume of the gas if the temperature is raised to 50°C while the pressure is held constant.

*Anggarkan isipadu gas jika suhu dinaikkan kepada 50°C manakala tekanan dipegang tetap.*

[4 marks]

[4 markah]

- CLO1 (c) A 2.00 L sample of dry air at 25°C and 1 atm contains 0.5493 g of O<sub>2</sub>, 1.7853 g of N<sub>2</sub> and 0.0327 g of Ar. Assuming ideal gas behaviour, and non-interacting.
- Given: Molecular weight of O<sub>2</sub> is 32 g/mol, N<sub>2</sub> is 28 g/mol, and Ar is 40 g/mol.
- Sampel 2.00 L udara kering pada 25°C dan 1 atm mengandungi 0.5493 g O<sub>2</sub>, 1.7853 g N<sub>2</sub> dan 0.0327 g Ar. Dengan mengandaikan kelakuan gas ideal, dan tidak berinteraksi.*
- Diberi: Berat molekul O<sub>2</sub> ialah 32 g/mol, N<sub>2</sub> ialah 28 g/mol, Ar ialah 40 g/mol*
- i) Calculate the partial pressure of each gas in the air.  
*Kirakan tekanan separa bagi setiap gas di udara.*
- [6 marks]  
[6 markah]
- ii) Calculate the mole fraction of each gas in the air.  
*Kirakan pecahan mol setiap gas di udara.*
- [7 marks]  
[7 markah]

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

CLO2

(a) Define the following items:

*Takrifkan perkara berikut:*

i) Potential Energy.

*Tenaga keupayaan.*

[2 marks]

[2 markah]

ii) Unit of the potential energy.

*Unit tenaga keupayaan.*

[2 marks]

[2 markah]

CLO2

(b) Methane at 87.5 mol/h enters a burner where it is burnt with 20% excess air. Air has 21 mol% oxygen and 79 mol% nitrogen. Assuming a complete combustion.

*Metana pada 87.5 mol/j memasuki penunu di mana ia dibakar dengan 20% lebihan udara. Udara mempunyai 21 mol% oksigen dan 79 mol% nitrogen. Dengan mengandaikan pembakaran lengkap, anggarkan*

i) Approximate the total moles of air entering the system in mol/h.

*Anggarkan jumlah mol udara yang memasuki sistem dalam mol/j.*

[4 marks]

[4 markah]

CLO2

- ii) Approximate the molar composition of the stack gas on a dry basis as it contains 60 moles %  $N_2$ , 15 moles %  $CO_2$ , 10 moles %  $O_2$ , and 15 moles %  $H_2O$ .

*Anggarkan komposisi molar gas tindakan secara kering kerana ia mengandungi 60 mol %  $N_2$ , 15 mol %  $CO_2$ , 10 mol %  $O_2$ , dan 15 mol %  $H_2O$ .*

[4 marks]

[4 markah]

- (c) A stream of nitrogen flowing at a rate of 200 mol/min is heated from 20°C to 100°C. The heat capacity of  $N_2$  at a constant pressure of 1 atm is:

*Aliran nitrogen yang mengalir pada kadar 200 mol/min dipanaskan daripada 20 °C hingga 100 °C. Muatan haba  $N_2$  pada tekanan malar 1 atm ialah:*

$$C_p[\text{kJ}/(\text{mol} \cdot ^\circ\text{C})] = 0.02900 + 0.2199 \times 10^{-5}T + 0.5723 \times 10^{-8}T^2 - 2.871 \times 10^{-12}T^3$$

Assuming idea-gas behaviour

*Dengan mengandaikan kelakuan gas idea.*

- i) Calculate the specific enthalpy  $\Delta \hat{H}$  (kJ/mol) of the nitrogen.

*Kirakan entalpi tentu  $\Delta \hat{H}$  (kJ/mol) nitrogen.*

[4 marks]

[4 markah]

- ii) Calculate the heat,  $Q$  (kJ/min) that must be transferred in this case.

*Kirakan haba,  $Q$  (kJ/min) yang mesti dipindahkan dalam kes ini.*

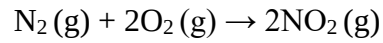
[4 marks]

[4 markah]



- iii) Nitrogen and oxygen gas react to form nitrogen dioxide according to the following reaction:

*Nitrogen dan gas oksigen bertindak balas membentuk nitrogen dioksida mengikut tindak balas berikut:*



Calculate the change in enthalpy for the above reaction, given:

*Kirakan perubahan dalam entalpi bagi tindak balas di atas, diberi:*



[5 marks]

[5 markah]

### SOALAN TAMAT

## Appendix 1

Table 1 Unit Conversions

| Quantity        | Equivalent Values                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mass</b>     | $1 \text{ kg} = 1000 \text{ g} = 0.001 \text{ metric ton} = 2.20462 \text{ lb}_m = 35.27392 \text{ oz}$<br>$1 \text{ lb}_m = 16 \text{ oz} = 5 \times 10^{-4} \text{ ton} = 453.593 \text{ g} = 0.453593 \text{ kg}$                                                                                                                                                                                                      |
| <b>Length</b>   | $1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 10^6 \text{ microns } (\mu\text{m}) = 10^{10} \text{ angstroms (A)}$<br>$= 39.37 \text{ in.} = 3.2808 \text{ ft} = 1.0936 \text{ yd} = 0.0006214 \text{ mile}$                                                                                                                                                                                                          |
| <b>Volume</b>   | $1 \text{ m}^3 = 1000 \text{ liters} = 10^6 \text{ cm}^3 = 10^6 \text{ ml}$<br>$= 35.3145 \text{ ft}^3 = 220.83 \text{ imperial gallons} = 264.17 \text{ gal} = 1056.68 \text{ qt}$<br>$1 \text{ ft}^3 = 1728 \text{ in}^3 = 7.4805 \text{ gal} = 0.028317 \text{ m}^3 = 28.317 \text{ liters}$<br>$= 28\,317 \text{ cm}^3$                                                                                               |
| <b>Force</b>    | $1 \text{ N} = 1 \text{ kg.m/s}^2 = 10^5 \text{ dynes} = 10^5 \text{ g.cm/s}^2 = 0.22481 \text{ lb}_f$<br>$1 \text{ lb}_f = 32.174 \text{ lbm.ft/s}^2 = 4.4482 \text{ N} = 4.4482 \times 10^4 \text{ dynes}$                                                                                                                                                                                                              |
| <b>Pressure</b> | $1 \text{ atm} = 1.01325 \times 10^5 \text{ N/m}^2 \text{ (Pa)} = 101.325 \text{ kPa} = 1.01325 \text{ bars}$<br>$= 1.01325 \times 10^6 \text{ dynes/cm}^2$<br>$= 760 \text{ mm Hg at } 0^\circ\text{C (torr)} = 10.333 \text{ m H}_2\text{O at } 4^\circ\text{C}$<br>$= 14.696 \text{ lb}_f/\text{in}^2 \text{ (psi)} = 33.9 \text{ ft H}_2\text{O at } 4^\circ\text{C}$<br>$= 29.921 \text{ in Hg at } 0^\circ\text{C}$ |
| <b>Energy</b>   | $1 \text{ J} = 1 \text{ N.m} = 10^7 \text{ ergs} = 10^7 \text{ dyne.cm}$<br>$= 2.778 \times 10^{-7} \text{ kW.h} = 0.23901 \text{ cal}$<br>$= 0.7376 \text{ ft-lb}_f = 9.486 \times 10^{-4} \text{ Btu}$                                                                                                                                                                                                                  |
| <b>Power</b>    | $1 \text{ W} = 1\text{J/s} = 0.23901 \text{ cal/s} = 0.7376 \text{ ft.lbf/s} = 9.468 \times 10^{-4} \text{ Btu/s}$<br>$= 1.341 \times 10^{-3} \text{ hp}$                                                                                                                                                                                                                                                                 |

Appendix IIFORMULAS & EQUATIONS

1.  $W = mg, F = mg$
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  $\rho = m/V$
4. Avogadro's Number =  $6.02 \times 10^{23}$
5. 
$$\text{number of moles} = \frac{\text{mass}}{\text{Molecular weight}}$$
6. 
$$\text{Mass Fraction, } x = \frac{m}{m_{Total}} \quad \text{and} \quad \text{Mole Fraction, } y = \frac{n}{n_{total}}$$
7. General Balance Equation for steady state process:  
input + generation = output + consumption
8. 
$$\text{Fractional excess} = \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}}$$
9. 
$$\text{percentage excess} = \frac{\text{moles}_{(fed)} - \text{moles}_{(reacted)}}{\text{moles}_{(reacted)}} \times 100\%$$
10. 
$$\text{fractional conversion, } f = \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}}$$
11. 
$$\% \text{ fractional conversion} = \frac{\text{moles}_{(reacted)}}{\text{moles}_{(Fed)}} \times 100\%$$
12. 
$$\text{Yield} = \frac{\text{moles}_{(desired product)}}{\text{moles}_{(LR)}} \times \frac{\text{stoichiometry coefficient}_{(LR)}}{\text{stoichiometry coefficient}_{(DP)}} \times 100\%$$
13. 
$$\text{Selectivity} = \frac{\text{moles}_{(desired product)}}{\text{moles}_{(undesired product)}}$$

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

15. 100 mol air  $\longrightarrow$  79 mol nitrogen  
 $\longrightarrow$  21 mol oxygen

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

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

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

19.  $T(\text{K}) = T(^{\circ}\text{C}) + 273$   
 $T(^{\circ}\text{R}) = T(^{\circ}\text{F}) + 460$   
 $T(^{\circ}\text{F}) = T(^{\circ}\text{C}) \frac{5}{9} + 32$

20. Standard Condition for gases

| System | $T_s$ | $P_s$ | $V_s$                  | $n_s$ |
|--------|-------|-------|------------------------|-------|
| SI     | 273K  | 1 atm | $0.022415 \text{ m}^3$ | 1 mol |

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

22. Kinetic Energy =  $\frac{1}{2} mv^2$

23. Potential Energy =  $mgh$

24. First Law of Thermodynamics for closed system:

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

25. Energy balance for closed system:

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

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

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