SULIT

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 : 2023/2024

DGP30132 : MASS AND ENERY BALANCE

TARIKH : 05 JANUARI 2024
MASA : 8.30 PAGI – 10.30PAGI (2 JAM)

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

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Tiada

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

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 (a) Define mass.

Takrifkan jisim.

[3 marks]

[3 markah]

CLO1 (b) Given that the density of water at 4°C is 1 g/cm^3. Approximate the mass of the following in g.

Diberi bahawa ketumpatan air pada 4°C ialah 1 g/cm^3. Anggarkan jisim berikut dalam g.

i) Substance A has a specific gravity of 1.5189 and the volume is 8 ft^3.

Bahan A mempunyai graviti tentu 1.5189 dan isipadunya ialah 8 ft^3.

[4 marks]

[4 markah]

ii) 50 gallons of acetic acid and the specific gravity of acetic acid is 1.022.

50 gelen asid asetik dan graviti tentu asid asetik ialah 1.022.

[5 marks]

[5 markah]

CLO1 (c) Calculate the following item which contains 5.38 kg of carbon dioxide, 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, CO_2
Diberi: Berat Atom C ialah 12 g/mol dan O ialah 16 g/mol.

i) the number of moles of carbon dioxide, CO_2.
bilangan mol karbon dioksida, 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 persamaan imbangan 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 overhed 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.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

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_2, 1.7853 g of N_2 and 0.0327 g of Ar. Assuming ideal gas behaviour, and non-interacting.

Given: Molecular weight of O_2 is 32 g/mol, N_2 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_2, 1.7853 g N_2 dan 0.0327 g Ar. Dengan mengandaikan kelakuan gas ideal, dan tidak berinteraksi.

Diberi: Berat molekul O_2 ialah 32 g/mol, N_2 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 tindanan 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:

$$C_p[kJ/(mol.°C)] = 0.02900 + 0.2199\times10^{-5}T + 0.5723\times10^{-8}T^2 - 2.871\times10^{-12}T^3$$

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:

$$N_2\,(g) + 2O_2\,(g) \rightarrow 2NO_2\,(g)$$

Calculate the change in enthalpy for the above reaction, given:
Kirakan perubahan dalam entalpi bagi tindak balas di atas, diberi:

$N_2\,(g) + O_2\,(g) \rightarrow 2NO\,(g)$ $\Delta H = 181$ kJ

$2NO\,(g) + O_2 \rightarrow 2NO_2\,(g)$ $\Delta H = -131$ kJ

[5 marks]
[5 markah]

SOALAN TAMAT

Appendix 1

Table 1 Unit Conversions

Quantity	Equivalent Values
Mass	1 kg = 1000 g = 0.001 metric ton = 2.20462 Ib_m = 35.27392 oz 1 Ib_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 Ib_f 1 Ib_f = 32.174 Ibm.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 ll

FORMULAS & EQUATIONS

1. W = mg, F=mg
2. $g = 9.8066\ m/s^2 = 980.66\ cm/s^2 = 32.174\ ft/s^2$
3. $SG = \rho / \rho_{ref}$
2. ρ_{ref} (H_2O, 4°C) = $1.000\ g/cm^3 = 1000\ kg/m^3 = 62.43\ Ib_m/ft^3$
3. Density $\rho = m/V$
4. Avogadro's Number = 6.02×10^{23}
5. $$number of\ moles = \frac{mass}{Molecular weight}$$
6. $$Mass\ Fraction, x = \frac{m}{m_{Total}} \quad \text{and} \quad Mole\ Fraction, y = \frac{n}{n_{total}}$$
7. General Balance Equation for steady state process:

   input + generation = output + consumption

8. $$Frational\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}}$$
9. $$percentage\ excess = \frac{moles_{(fed)} - moles_{(reacted)}}{moles_{(reacted)}} \times 100\%$$
10. $$fractional\ conversion, f = \frac{moles_{(reacted)}}{moles_{(Fed)}}$$
11. $$\%\ fractional\ conversion = \frac{moles_{(reacted)}}{moles_{(Fed)}} \times 100\%$$
12. $$Yield = \frac{moles_{(desired\ product)}}{moles_{(LR)}} \times \frac{stoichiome\ try\ coefficien\ t_{(LR)}}{stoichiome\ try\ coefficien\ t_{(DP)}} \times 100\%$$
13. $$Selectivity = \frac{moles_{(desired\ product)}}{moles_{(undesired\ product)}}$$

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

15. 100 mol air ⟶ 79 mol nitrogen

⟶ 21 mol oxygen

16. Ideal gas law : PV = nRT : $\dfrac{PV}{P_sV_s} = \dfrac{nT}{n_sT_s}$: $\dfrac{P_1V_1}{P_2V_2} = \dfrac{T_1}{T_2}$

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

18. 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

19. T (K) = T (˚C) + 273

T (˚R) =T (˚F) + 460

T(°F) = T(°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 m^3	1 mol

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

22. Kinetic Energy = ½ mv^2

23. Potential Energy = mgh

24. First Law of Thermodynamics for closed system:

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

25. Energy balance for closed system:

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

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

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