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 the specific gravity, SG.

Takrifkan graviti tentu, SG.

[3 marks]

[*3 markah*]

CLO1 (b) Approximate the density of the following in lb_m/ft^3

Anggarkan ketumpatan berikut dalam lb_m/ft^3

i) A liquid with density of 860kg/m^3 using a conversion factor table.

Cecair dengan ketumpatan 860kg/m^3 menggunakan jadual factor penukaran.

[4 marks]

[*4 markah*]

ii) A metal bar with mass 100g and volume dimension of 2cm x 1.5cm x 3cm.

Satu bar logam dengan jisim 100g dan dimensi isipadu ialah 2cm x 1.5cm x 3cm.

[5 marks]

[*5 markah*]

CLO1 (c) Calculate the following item which contains 2.5kg of Methane, CH_4

Given: Atomic Weight of C is 12g/mol and H is 1g/mol

Kirakan item berikut yang mengandungi 2.5kg metana, CH_4

Diberi: Berat Atom C ialah 12g/mol dan H ialah 1g/mol

i) the number of moles of methane, CH_4

*bilangan mol met*ana, CH_4

[4 marks]

[*4 markah*]

ii) the number of moles of C atoms

bilangan mol atom C

[4 marks]

[*4 markah*]

iii) the mass of H atoms

jisim bagi atom H

[5 marks]

[*5 markah*]

QUESTION 2

SOALAN 2

CLO2 (a) Material balances is obeying the law of conservation of mass where the mass can neither be created nor destroyed.

Keseimbangan bahan adalah mematuhi undang – undang pemuliharaan jisim dimana jisim tidak boleh dicipta atau dimusnahkan.

i) State the general balance equation of theory material balance.

Nyatakan persamaan keseimbangan umum bagi teori baki bahan.

[2 marks]

[*2 markah*]

ii) Define the steady-state condition.

Takrifkan keadaan mantap.

[2 marks]

[*2 markah*]

CLO2 (b) 2000kg/h liquid mixture containing 70wt% ethanol and the balance of water. A stream of this mixture is fed to a separator vessel and operating under steady-state conditions. Product streams emerge at the distillate and residue streams. 85% of the water-fed recovery in the residue stream and the distillate streams contains 75wt% ethanol.

2000kg/j campuran cecair yang mengandungi 75wt% etanol dan keseimbangan air. Aliran campuran ini masuk ke dalam pemisah vessel dan beroperasi di bawah keadaan-mantap. Aliran produk muncul di aliran sulingan dan sisa. 85% daripada pemulihan yang diberi air dalam aliran sisa dan aliran sulingan mengandungi 75wt% etanol.

i) Draw a flowchart of the process with complete labeling

Lukiskan carta alir proses dengan penglabelan lengkap

[3 marks]

[*3 markah*]

ii) Calculate all unknown variable in process flowchart

Kirakan semua pemboleh ubah tidak diketahui dalam carta alir proses

[6 marks]

[*6 markah*]

CLO2 (c) The molar composition of feed streams consists of 40% H_2O_2 and the balance of O_3 is fed an oxidation reactor. This reactor operating under steady state with the fractional conversion of H_2O_2 is 0.68. Take a 200 mol feed as basic calculation. Consider the reaction below:

Komposisi molar aliran suapan terdiri daripada 40% H_2O_2 dan baki O_3 masuk ke dalam reaktor pengoksidaan. Reaktor ini beroperasi keadaan stabil dengan penukaran pecahan H_2O_2 ialah 0.68. Ambil suapan 200 mol sebagai asas pengiraan. Pertimbangkan reaksi dibawah:

$$H_2O_2 + O_3 \rightarrow H_2O + 2O_2$$

i) Calculate the extent of reaction.

Kirakan takat tindak balas

[6 marks]

[*6 markah*]

ii) Calculate the molar products of each species as it exits the reactor.

Kirakan produk molar bagi setiap spesies semasa ia keluar dari reaktor

[6 marks]

[*6 markah*]

QUESTION 3

SOALAN 3

CLO1

(a) Define the following items

Takrifkan perkara berikut

i) Ideal gas

Gas ideal

[2 marks]

[*2 markah*]

ii) Unit of gas constant, R

Unit pemalar gas, R

[2 marks]

[*2 markah*]

CLO1

(b) 200L of nitrous oxide gas is being stored in a pressure vessel at absolute 250bar and temperature of 20^{o}C. The nitrous oxide is fed into a heated chamber, where the temperature is raised up to 80^{o}C, and pressure is reduced to 5bar. By assuming the ideal gas system.

200L gas nitrous oksida disimpan dalam vesel tekanan pada 250 bar mutlak dan suhu 20^{o}C. Nitrous oksida dimasukkan ke dalam ruang yang dipanaskan, dimana suhu meningkat kepada 80^{o}C dan tekanan dikurangkan kepada 5bar. Dengan mengandaikan sistem gas ideal.

i) Approximate the mole of gas in pressure vessel.

Anggarkan bilangan mol gas dalam vesel tekanan.

[4 marks]

[*4 markah*]

ii) Approximate the volume in liter (L) occupied in heated chamber.

Anggarkan isipadu dalam liter (L) yang memenuhi ruang pemanas.

[4 marks]

[*4 markah*]

CLO2 (c) At 100°C and 10 atm, a stream of steam with flowrate at $10m^3/h$ is mixed with a stream of air that contains 21mol% Oxygen and the rest is Nitrogen at flowrate 150mol/h. The gases mixture is then kept inside the container at a 12 atm absolute pressure. By assuming the ideal gas system.

Pada 100^oC dan 10 atm, aliran wap dengan kadaran aliran pada 10m3/h dicampur dengan aliran udara yang mengandungi 21mol% Oksigen dan selebihnya Nitrogen pada kadar aliran 150mol/j. Gas Campuran kemudian disimpan di dalam bekas pada tekanan mutlak 12 atm. Dengan mengandaikan sistem gas ideal.

i) Calculate the molar flowrate of each species in the container.
Kirakan kadar aliran molar bagi setiap spesies dalam bekas.

[6 marks]
[*6 markah*]

ii) Calculate the partial pressure of each species
Kirakan tekanan separa bagi setiap spesies

[7 marks]
[*7 markah*]

QUESTION 4

SOALAN 4

CLO1 (a) Define the following items

Takrifkan perkara berikut

i) Kinetic Energy

Tenaga kinetik

[2 marks]

[*2 markah*]

ii) Unit of the kinetic energy

Unit tenaga kinetik

[2 marks]

[*2 markah*]

CLO2 (b) 100mol of butane is fed into a burner chamber with 30% excess air. Assuming complete combustion occurs.

100mol butana dimasukkan ke dalam ruang pembakar dengan udara berlebihan 30%. Dengan mengandaikan pembakaran lengkap berlaku.

i) Approximate the total mol of air fed into burner chamber

Anggarkan jumlah mol udara yang dimasukkan ke dalam ruang pembakar.

[4 marks]

[*4 markah*]

ii) In stack gas of burner chamber contains 74% N_2, 9% CO_2, 5% O_2 and the balance H_2O. Approximate the composition of the gas on an orsat analysis (dry basis).

Dalam timbunan gas ruang pembakar mengandungi 74% N_2, 9% CO_2, 5% O_2 and baki H_2O. Anggarkan komposisi gas pada analisis orsat (asa kering).

[4 marks]

[*4 markah*]

CLO2 (c) In the following process, water is being evaporated for use in a large-scale steam-methane reforming plant. The steam exiting the evaporator will be mixed with a methane stream. The water stream is required to be heated from 150 to 300°C. Given the polynomial heat capacity formula for steam is:

Dalam proses berikut, air akan disejatkan untuk diguna dalam loji pembaharuan metana stim berskala besar. Wap yang keluar dari penyejat akan dicampur dengan aliran metana. Aliran air perlu dipanaskan dari 150 hingga 300°C. Diberikan formula kapasiti haba polynomial untuk stim adalah:-

$$C_v\ (kJ/mol.^oC) = 33.46 \times 10^{-3} + 0.688 \times 10^{-5}T$$

i) Calculate the $\Delta\tilde{U}$ (kJ/mol) of steam.

Kirakan $\Delta\tilde{U}$ (kJ/mol) bagi wap

[4 marks]

[*4 markah*]

ii) Calculate the heat, Q (kJ/min) if the molar flowrate is 200mol/h.

Kirakan haba, Q (kJ/min), jika kadar aliran molar ialah 200mol/j.

[4 marks]

[*4 markah*]

iii) Calculate the heat reaction of steam-methane reforming according to the heat formation given below:

Kirakan tindak balas haba pembaharuan metana-stim mengikut pembentukan haba yang diberikan di bawah:

$$CH_4\ (g) + H_2O\ (g) \rightarrow CO\ (g) + 3H_2\ (g)$$

Given the heat formation:

Diberi haaba pembetukan:

$2C + O_2 \rightarrow 2CO$	$\Delta H_f = -\ 221.04$ kJ
$2H_2 + O_2 \rightarrow 2H_2O$	$\Delta H_f = -\ 571.68$ kJ
$C + 2H_2 \rightarrow CH_4$	$\Delta H_f = -\ 74.85$ 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

CHAPTER 1

1. W = mg

2. g = 9.8066 m/s^2 = 980.66 cm/s^2 = 32.174 ft/s^2

3. SG = ρ / ρ_{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 ρ = m/V

4. Avogadro's Number = 6.02 X 10^{23}

5. $$number\,of\;\;moles = \frac{mass}{Molecular\;weight}$$

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 $\longrightarrow$ 79 mol nitrogen

$\longrightarrow$ 21 mol oxygen

CHAPTER 3

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

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) + 32

5. Standard Condition for gases

System	$\mathbf{T_s}$	$\mathbf{P_s}$	$\mathbf{V_s}$	$\mathbf{n_s}$
SI	273 K	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 = ½ 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 $\Delta H = \sum n\,\Delta H_{(products)} - \sum n\Delta H_{(reactants)}$