

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) State the **THREE (3)** conditions that allows batch reactors to operate well in petrochemical industry.
*Senaraikan **TIGA (3)** keadaan yang membolehkan reaktor kelompok boleh beroperasi dengan baik di industri petrokimia.*
- [3 marks]
[3 markah]
- CLO1 (b) Batch reactors are also used in several industries producing small quantities of high-valued materials such as polymer synthesis and crystallization.
Reaktor kelompok juga digunakan dalam beberapa industri yang menghasilkan kuantiti kecil bahan bernilai tinggi seperti sintesis polimer dan penghabluran.
- i) Explain **TWO (2)** advantages of this reactor in the petrochemical industry.
*Terangkan **DUA (2)** kelebihan reaktor ini di dalam industri petrokimia.*
- [4 marks]
[4 markah]
- ii) Discuss **TWO (2)** disadvantages of batch reactors that would impact the processing plant in industries.
*Bincangkan **DUA (2)** kelemahan reaktor kelompok yang akan memberi kesan kepada loji pemprosesan dalam industri.*
- [4 marks]
[4 markah]

CLO1

- (c) Given an example of chemical reaction, the combustion reaction of liquid ethanol (C_2H_5OH) at high temperature will yield carbon dioxide gas together with water vapour.

Diberi contoh seebuah tindak balas kimia, tindak balas pembakaran etanol cecair (C_2H_5OH) pada suhu tinggi akan menghasilkan gas karbon dioksida bersama-sama dengan wap air.

- i) Write the complete chemical equation for this complete combustion process, complete together with its rate law and overall reaction order.
Tulis persamaan kimia lengkap untuk tindak balas proses pembakaran lengkap ini, lengkap bersama-sama dengan undang-undang kadar dan susunan tindak balas keseluruhan.

[6 marks]

[6 markah]

- ii) Based on the reaction at Question 1 c (i), given the rate of disappearance of ethanol is $20 \text{ mol} / \text{dm}^3 \cdot \text{s}$, calculate the rate of disappearance of oxygen as well as rate of formation for carbon dioxide and water vapour.
Berdasarkan tindak balas Soalan 1 c (i), memandangkan kadar kehilangan etanol adalah $20 \text{ mol} / \text{dm}^3 \cdot \text{s}$, kira kadar kehilangan oksigen serta kadar pembentukan karbon dioksida dan wap air.

[8 marks]

[8 markah]

QUESTION 2**SOALAN 2**

CLO1

- (a) State **THREE (3)** applications of Continuous Stirred Tank Reactor (CSTR) that are used in the processing plant.

*Nyatakan **TIGA (3)** aplikasi Reaktor Tangki Teraduk Berterusan (CSTR) yang digunakan di loji pemprosesan.*

[3 marks]

[3 markah]

- CLO1 (b) CSTR also functions to facilitate chemical manufacturing in continuous flow and have been used for decades in petrochemical industry.
CSTR juga berfungsi untuk memudahkan pembuatan kimia dalam aliran berterusan dan digunakan selama beberapa dekad dalam industri petrokimia.
- i) Discuss **TWO (2)** advantages of using CSTR in this industry.
*Bincangkan **DUA (2)** kelebihan menggunakan CSTR dalam industri ini.*
[4 marks]
[4 markah]
- ii) Explain **TWO (2)** disadvantages when choosing CSTR as the reactor for chemical processes.
*Terangkan **DUA (2)** kelemahan apabila memilih CSTR sebagai reaktor untuk proses kimia.*
[4 marks]
[4 markah]
- CLO2 (c) The production of liquid antibiotic Medicine A (Med-A) uses CSTR in series configuration. 4000 mol/s of Med-A is fed into the CSTR 1 with a capability of 250 L and conversion of 85%. Then, mixtures from CSTR 1 are fed into CSTR 2 for completed product with final product flow rate in CSTR 2 of 200 mol/s and capability of CSTR 2 running twice the volume of CSTR 1. Calculate:
Pengeluaran ubat antibiotik cecair A (Med-A) menggunakan CSTR dalam konfigurasi siri. 4000 mol/s Med-A dimasukkan ke dalam CSTR 1 dengan keupayaan 250 L dan penukaran sebanyak 85%. Kemudian, campuran dari CSTR 1 dimasukkan ke dalam CSTR 2 untuk produk siap dengan kadar aliran produk akhir dalam CSTR 2 daripada 200 mol/s dan keupayaan CSTR 2 berjalan adalah dua kali ganda isi padu CSTR 1. Kira:
- i) The reaction rate for CSTR 1 and the final product flow rate of Med-A for CSTR 1.
Kadar tindak balas untuk CSTR 1 dan kadar aliran produk akhir Med-A untuk CSTR 1.
[6 marks]
[6 markah]

- ii) The reaction rate for CSTR 2 as well as the percentage conversion for CSTR 2.

Kadar tindak balas untuk CSTR 2 serta peratusan penukaran untuk CSTR 2.

[8 marks]

[8 markah]

QUESTION 3

SOALAN 3

CLO1

- (a) State **THREE (3)** chemical processes examples that use Plug Flow Reactor (PFR) as their main reactor.

Nyatakan TIGA (3) contoh proses kimia yang menggunakan Reaktor Aliran Palam (PFR) sebagai reaktor utama mereka.

[3 marks]

[3 markah]

CLO1

- (b) The design of PFR allows for precise control over reaction time, temperature and reactant concentration, which can help to optimize product yield and purity.

Reka bentuk PFR membolehkan kawalan tepat ke atas masa tindak balas, suhu dan kepekatan bahan yang bertindak balas, yang boleh membantu untuk hasil dan ketulenan produk yang optimum.

- i) Discuss **TWO (2)** design operations which may be also described as mode of operations of this reactor.

Bincangkan DUA (2) operasi reka bentuk yang juga boleh digambarkan sebagai mod operasi reaktor ini.

[4 marks]

[4 markah]

- ii) Explain **TWO (2)** advantages using this typical reactor in the petrochemical industry.

Terangkan DUA (2) kelebihan menggunakan reaktor biasa ini dalam industri petrokimia.

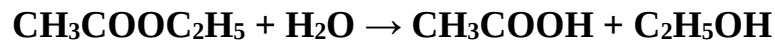
[4 marks]

[4 markah]

CLO2

- (c) Given the hydrolysis reaction of ethyl acetate in liquid phase is in the First Order reaction as shown below.

Diberi tindak balas yang hidrolisis etil asetat dalam fasa cecair adalah dalam tindak balas Tertib Pertama seperti yang ditunjukkan di bawah.



The reaction will produce acetic acid solution as well as ethanol solution as the products. The reaction process runs isothermally at 700 K with initial flow rate of 8000 gmol/s and reactant initial concentration of 4.0 gmol/L. The reaction has a rate constant of 6 s^{-1} with final conversion of 90%.

Tindak balas akan menghasilkan larutan asid asetik serta larutan etanol sebagai produk. Proses tindak balas berjalan secara isoterma pada 700 K dengan kadar aliran awal 8000 gmol / s dan kepekatan awal bahan tindak balas 4.0 gmol / L. Pemalar kadar tindak balas 6 s^{-1} dengan penukaran akhir 90%.

- i) Write the First Order (1st Order) rate law of the reaction and the rate of reaction equation of this process.

Tulis tertib pertama undang-undang kadar tindak balas dan persamaan kadar tindak balas proses ini.

[6 marks]

[6 markah]

- ii) Calculate the volume size of the PFR required in this process. (Put your final answer in 2 decimal places.)

Hitung saiz isi padu PFR diperlukan. (Letakkan jawapan terakhir anda di 2 tempat perpuluhan.)

[8 marks]

[8 markah]

*By using calculation formula:

$$V_R = F_{Ao} \int_0^{X_{Af}} \frac{1}{-r_A} dX_A$$

$$\int_0^{x_1} \frac{1}{1-x} dx = \ln \frac{1}{1-x_1}$$

QUESTION 4

SOALAN 4

CLO1

- (a) State **THREE (3)** types of bubble column reactor that are used in the petrochemical industry.

*Nyatakan **TIGA (3)** jenis reaktor turus gelembung yang digunakan dalam industri petrokimia.*

[3 marks]

[3 markah]

CLO1

- (b) Fixed bed reactors and fluidized bed reactors are also used as the main reactor in the processing plant especially in refinery and petrochemical complex.

Reaktor lapisan tetap dan reaktor lapisan terbendalir juga digunakan sebagai reaktor utama di kilang pemprosesan terutamanya di kompleks penapisan dan petrokimia.

- i) Explain **TWO (2)** process applications which use fluidized bed reactors as the main reactor with suitable parameters of pressure and temperature.
*Jelaskan **DUA (2)** aplikasi proses yang menggunakan sistem reaktor lapisan terbendalir sebagai reaktor utama dengan parameter tekanan dan suhu yang sesuai.*

[4 marks]

[4 markah]

- ii) Discuss **TWO (2)** advantages of choosing fixed bed reactors compared to other reactors.

*Bincangkan **DUA (2)** kelebihan memilih reaktor lapisan tetap berbanding reaktor lain.*

[4 marks]

[4 markah]

CLO2

- (c) Homogenous and heterogenous reactors refer to several types of chemical reactors based on the uniformity of the reaction mixture.

Reaktor homogen dan heterogen merujuk kepada pelbagai jenis reaktor kimia berdasarkan keseragaman campuran tindak balas.

- i) Given the synthesis process of aluminium oxide as below:

Diberi proses sintesis aluminium oksida seperti di bawah:



Based on the equation above, assign **THREE (3)** characteristics of this reaction.

*Berdasarkan persamaan di atas, berikan **TIGA (3)** ciri tindak balas ini.*

[6 marks]

[6 markah]

- ii) Hydrogenation process of acetylene from the cracked gas process in the ethylene cracker plant is the example of process that involves a reactor with solid and gas reactant. Draw **TWO (2)** reactor types that have these similar types of reactants with complete labels.

*Proses penghidrogenan asetilena dari gas proses pemecahan di loji pemecahan etilena adalah contoh proses yang melibatkan reaktor dengan bahan tindak balas pepejal dan gas. Lukis **DUA (2)** jenis reaktor yang mempunyai jenis bahan tindak balas yang serupa dengan label lengkap.*

[8 marks]

[8 markah]

SOALAN TAMAT