

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan struktur. Jawab **SEMUA** soalan.*

QUESTION 1**SOALAN 1**

Chemical reactors are vessels designed to contain chemical reactions. The design of a chemical reactor deals with multiple aspects of chemical engineering.

Reaktor kimia adalah vesel yang direka untuk mengandungi tindak balas kimia. Reka bentuk reaktor kimia berkaitan dengan pelbagai aspek kejuruteraan kimia.

CLO1
C1

- (a) State **THREE (3)** general types of chemical reactor.
*Senaraikan **TIGA (3)** jenis reaktor kimia yang umum.*

[3 marks]

[3 markah]

CLO1
C2

- (b) Chemical reactors can be classified according to their parameters such as feed and product flow, flow regime and others.

Reaktor kimia boleh dikelaskan mengikut parameter mereka seperti aliran bahan suapan dan produk, rejim aliran dan lain-lain.

- i) Explain **FOUR (4)** applications of a reactor in which the feed and product does not flow in or out during the reaction and the reactor is equipped with an agitation system.

*Terangkan **EMPAT (4)** penggunaan reaktor di mana aliran suapan dan produk tidak mengalir masuk atau keluar semasa tindak balas dan reaktor dilengkapi dengan sistem pengadukan.*

[4 marks]

[4 markah]

CLO2
C3

- ii) Discuss **FOUR (4)** advantages of a reactor that contain the mixture of fluid elements but no flow coming in and out based on your answer in b(i).

Bincangkan EMPAT (4) kelebihan reaktor yang mengandungi pencampuran unsur bendalir tetapi tiada aliran masuk dan keluar berdasarkan jawapan anda di b(i).

[4 marks]

[4 markah]

- (c) Rate of reaction is the rate at which species lose their chemical identity per unit volume. As an example, in a complete combustion process of butane (C_4H_{10}) with presence of oxygen, carbon dioxide gas will be produced together with some amount of water vapour from this reaction.

Kadar tindak balas adalah kadar di mana spesies kehilangan identiti kimia per unit isipadu. Sebagai contoh, dalam proses pembakaran lengkap butana (C_4H_{10}) dengan kehadiran oksigen, gas karbon dioksida akan dihasilkan bersama-sama dengan sejumlah wap air daripada tindak balas ini.

- i) Write the complete chemical equation for this reaction of the complete combustion process of butane, complete together with its rate law and overall reaction order.

Tulis persamaan kimia lengkap untuk tindak balas proses pembakaran lengkap butana 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 butane is $10 \text{ mol} / \text{dm}^3 \cdot \text{s}$, calculate the rate of disappearance of oxygen as well as rate of formation for carbon dioxide and water vapour. Berdasarkan tindak balas pada Soalan 1 c (i), memandangkan kadar kehilangan butana adalah $10 \text{ mol} / \text{dm}^3 \cdot \text{s}$, mengira kadar kehilangan oksigen serta kadar pembentukan karbon dioksida dan wap air.

[8 marks]

[8 markah]

QUESTION 2

SOALAN 2

Continuous stirred tank reactor (CSTR) is a reactor that generally runs at steady state with continuous flow of reactants and products.

Reaktor tangki teraduk berterusan (CSTR) adalah reaktor yang biasanya dijalankan pada keadaan stabil dengan aliran tindak balas dan produk yang berterusan.

CLO1
C1

- (a) State **THREE (3)** characteristics of CSTR that is used in the processing plant.
*Nyatakan **TIGA (3)** ciri-ciri CSTR yang digunakan di loji pemprosesan.*

[3 marks]

[3 markah]

CLO1
C2

- (b) CSTR is also widely used in specific processes such as continuous hydrogen production, used as a bioreactor for biohydrogen production and others.

CSTR juga digunakan secara meluas dalam proses tertentu seperti pengeluaran hidrogen berterusan, digunakan sebagai bioreaktor untuk pengeluaran biohidrogen dan lain-lain.

- i) Explain **FOUR (4)** design mode operation of this reactor.

*Terangkan **EMPAT (4)** operasi mod reka bentuk reaktor ini.*

[4 marks]

[4 markah]

- ii) Discuss **FOUR (4)** advantages of choosing CSTR as the reactor for chemical processes.

*Bincangkan **EMPAT (4)** kelebihan memilih CSTR sebagai reaktor untuk proses kimia.*

[4 marks]

[4 markah]

CLO2
C3

- (c) The production of high density polyethylene A-type (HDPE_A) in the CSTR series configuration process with 3000 mol/s of HDPE_A is fed into the CSTR 1 with a capability of 600L and conversion of 80%. Meanwhile, CSTR 2 is capable of running half of the volume of CSTR 1 and the final product HDPE_A flow rate in CSTR 2 is 120 mol/s. Calculate:

Proses pengeluaran polietilena ketumpatan tinggi jenis A (HDPE_A) dalam proses konfigurasi CSTR bersiri dengan 3000 mol/s suapan HDPE_A di masukkan ke dalam CSTR 1 dengan keupayaan isipadu sebanyak 600L dan penukaran sebanyak 80%. Sementara itu, CSTR 2 mampu menjalankan separuh daripada jumlah CSTR 1 dan kadar aliran produk akhir HDPE_A dalam CSTR 2 ialah 120 mol/s. Hitung:

- i) The reaction rate for CSTR 1 and the final product rate HDPE_A for CSTR 1.

Kadar tindak balas untuk CSTR 1 dan kadar produk akhir HDPE_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**

A typical of chemical reaction can be divided into homogeneous reaction and heterogeneous reaction.

Dalam tindak balas kimia biasa, ia boleh dibahagikan kepada tindak balas homogen dan tindak balas heterogen.

CLO1
C1

- (a) Describe why the solid phase is not classified in the homogeneous reaction.

Jelaskan mengapa fasa pepejal tidak dikelaskan dalam tindak balas homogen.

[3 marks]

[3 markah]

CLO1
C2

- (b) Homogenous and heterogenous reactions have their own reaction and differ from each other.

Tindak balas homogen dan heterogen mempunyai tindak balas mereka tersendiri dan berbeza antara satu sama lain.

- i) Explain **FOUR (4)** examples of homogeneous reaction processes.

*Terangkan **EMPAT (4)** contoh proses tindak balas homogen.*

[4 marks]

[4 markah]

- ii) Discuss the meaning of heterogeneous reaction process.

Bincangkan makna proses tindak balas heterogenous.

[4 marks]

[4 markah]

CLO2
C3

- (c) Given a reaction in gas phase and the reaction equation with first order (1st order) reaction as shown below.

Diberi tindak balas yang dalam fasa gas dan persamaan tindak balas dengan tindak balas tertib pertama seperti yang ditunjukkan di bawah.

A → Product

The reaction process runs isothermally at 800 K with initial flow rate of 10,000 gmol/s and reactant initial concentration of 2.0 gmol/L. The reaction has a rate constant of 5 s⁻¹ with the final conversion of 95%.

Proses tindak balas berjalan secara isoterma pada 800 K dengan kadar aliran awal 10,000 gmol / s dan kepekatan awal bertindak balas 2.0 gmol / L. Reaksi ini mempunyai pemalar kadar 5 s⁻¹ dengan penukaran akhir sebanyak 95%.

- i) Write the first order rate law of the reaction and the rate of reaction equation of this plug flow reactor (PFR).

Tulis tertib pertama undang-undang kadar tindak balas dan persamaan kadar tindak balas reaktor aliran palam ini (PFR).

[6 marks]

[6 markah]

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

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

[8 marks]

[8 markah]

*Given the calculation formula:

$$\int_{x_1}^{x_2} \frac{1}{1-x} dx = \ln \frac{1}{1-x_2} - \ln \frac{1}{1-x_1}$$

QUESTION 4**SOALAN 4**

Chemical reactors are pieces of equipment in which the feedstock is converted into the desired product. Bubble column reactor, fixed bed reactor and fluidized bed reactor are common reactors used in the process industries based on their special characteristics.

Reaktor kimia ialah kepingan peralatan di mana bahan mentah ditukar kepada produk yang dikehendaki. Reaktor lajur gelembung, reaktor katil tetap dan reaktor katil terbendalir adalah reaktor biasa yang digunakan dalam industri proses berdasarkan ciri khasnya.

CLO1
C1

- (a) State **THREE (3)** types of fixed bed reactor in the processing plant.
*Nyatakan **TIGA (3)** jenis reaktor lapisan tetap dalam loji pemprosesan.*

[3 marks]

[3 markah]

CLO1
C2

- (b) Bubble column reactor have their own speciality and are widely used for several processes in processing plants.

Reaktor turus gelembung mempunyai keistimewaan mereka tersendiri dan digunakan secara meluas untuk beberapa proses dalam loji pemprosesan.

- i) The production of Acetic Acid from methanol feed is the process that involves the bubble column reactor used as the main reactor of the process. Discuss other **FOUR (4)** process examples which focus on this reactor system.

*Penghasilan Asid Asetik dari bahan suapan etanol adalah proses yang terlibat dengan reaktor turus bergelembung yang digunakan sebagai reaktor utama dalam proses ini. Bincangkan **EMPAT (4)** contoh proses lain yang memberi tumpuan kepada sistem reaktor ini.*

[4 marks]

[4 markah]

CLO2
C3

- ii) Example **FOUR (4)** types of bubble column reactor that are used in the processing plant.

Contohkan EMPAT (4) jenis reaktor turus gelembung yang digunakan di loji pemprosesan.

[4 marks]

[4 markah]

- (c) The Fluidized bed *Fischer-Tropsch* (F-T) Synthesis and Fluidized Catalytic Cracking (FCC) are the processes involved with the fluidized bed reactor that is used as the main reactor of the process.

Sintesis Fischer-Tropsch (F-T) secara lapisan terbendalir dan pemecahan bermangkin terbendalir adalah proses yang terlibat dengan reaktor lapisan terbendalir yang digunakan sebagai reaktor utama dalam proses ini.

- i) Show the phenomena of catalyst fluidization process which can be described as the fluidization characteristics in the fluidized bed reactor.

Tunjukkan fenomena proses pembendaliran bermangkin yang boleh digambarkan sebagai ciri-ciri pembendaliran di dalam reaktor lapisan terbendalir.

[6 marks]

[6 markah]

- ii) Write the characteristics of a fluidized bed reactor with a complete schematic diagram for the reactor.

Tulis ciri-ciri reaktor lapisan terbendalir dengan rajah skematik lengkap untuk reaktor ini.

[8 marks]

[8 markah]

SOALAN TAMAT