Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	CHEMICAL REACTION ENGINEERING
COURSE CODE	:	DAK 22303
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	JULY 2024
DURATION	:	2 HOURS AND 30 MINUTES
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 Chemical process can only take place once raw materials completed the treatment steps.

(a) Explain physical treatment steps and chemical treatment steps in chemical process.

(4 marks)

(b) Write two (2) ways to slow down a chemical process.

(4 marks)

(c) Combustion of ethane takes place in a cylindrical reactor and the equation is given as below. This reaction will produce 3 kg/s of H_2O while 100 mol $O_2/(m^3.sec)$ of oxygen gas, O_2 will be consumed.

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

(i) Calculate the reactor height, given that the reactor diameter is 1 meter.

(5 marks)

(ii) Name the component A, B, C and D for this process.

(4 marks)

(d) Explain the size and operation advantage for batch reactor

(2 marks)

(e) Explain the size and operation advantage for CSTR and PFR

(6 marks)

Q2 Conversion value is an important indicator of the completion of a chemical process.

(a) Based on these symbols of N_A, N_{A0}, X.

(i) Rearrange these symbols into conversion equation.

(2 marks)

(ii) Explain the impact on the N_A value when X value is increased.

(4 marks)

(b) The combustion of Magnesium, $2Mg + O_2 \rightarrow 2MgO$ is performed with molar flow rate of 20 mole of Mg per second with conversion of $X = 60\%$. Calculate CSTR and PFR volumes based on reaction data in **APPENDIX A.1**.

(10 marks)

(c) A chemical reaction is carried out via series of reactors with the following sequence and conversion values of PFR (25%) → CSTR (20%) → CSTR (20%). The molar flowrate, F_{A0} is fixed at 10 mol/s. Based on reaction data in **APPENDIX A.1**, calculate the individual volume of these reactors.

(9 marks)

Q3 Rate law equation is an indicator of the speed of a chemical reaction.

(a) Based on the reaction of $2Na + Cl_2 \rightarrow 2NaCl$.

(i) Write the elementary rate law equation.

(2 marks)

(ii) State the reaction order for Na and Cl_2.

(2 marks)

(iii) Calculate the overall reaction order.

(2 marks)

(iv) Write the reversible rate law equation.

(3 marks)

(b) Chemical reaction can be identified by the their molecularity.

(i) Explain molecularity of a chemical reaction.

(4 marks)

(ii) Write examples of unimolecular, bimolecular and termolecular reaction.

(6 marks)

(iii) Write the rate law for all three (3) reactions in **Q3(b)(ii)**.

(6 marks)

Q4 Stoichiometric table is used to monitor movement of components in chemical reaction.

(a) Write the complete the stoichiometric table from the **APPENDIX A.2** into your answer script using the symbol N_A. The chemical reaction of this batch reactor is $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$, while the inert component is Argon.

(10 marks)

(b) Reaction can be carried out with the aid of catalyst. Sketch a diagram for each five (5) steps in catalytic reaction of $C_2H_4 + H_2 \rightarrow C_2H_6$.

(15 marks)

- END OF QUESTIONS -

APPENDIX A

APPENDIX A.1

X	$-r_A$ $(mol/m^3.s)$
0.00	4.1
0.20	3.4
0.25	3.2
0.30	2.9
0.45	2.6
0.60	2.03
0.65	1.54
0.70	1.15
0.75	1.45
0.80	1.03

APPENDIX A.2

Species Name	Symbol	Molar, *Ni (mol)*		
		Initial *(mol)*	Change *(mol)*	Final *(mol)*
				N_A =
				N_B =

List of Formula

Batch reactor: $V = \frac{N_{A0}}{t} \int_{X(0)}^{X(t)} \frac{dX}{-r_A}$ Batch reactor time: $t = C_{A0} \int_{X(0)}^{X(t)} \frac{dX}{-r_A}$

CSTR: $V = \frac{(F_{A0}X)}{-r_A}$ CSTR in series: $V = F_{A0}(X_1 - X_0) \div -$

r_A

PFR: $V = F_{A0} \int_{X(0)}^{X(t)} \frac{dX}{-r_A}$

Simpson's trapezoidal rule (two-point rule),

$$\int_{X0}^{X1} f(X)\, dX = \frac{h}{2}[f(X_0) + f(X_1)]$$

Simpson's one third rule (three point rule),

$$\int_{X0}^{X2} f(X)\, dX = \frac{h}{6}[f(X_0) + 4f(X_1) + f(X_2)]$$

Where, $f(X_0)$ is the value of $1 / (-r_A)$ at point X_0 and h is the distance between conversion points.

$C_{A0} = N_{A0} \div V$

$k = Ae^{\frac{-E}{RT}}$

$C_A = C_{A0}(1 - X)$

$F_A = F_{A0}(1 - X)$

$$\int_{\square}^{\square} \frac{1}{(1-X)^2}\, dX = \frac{1}{(1-X)}$$

$Da = \frac{-r_A V}{F_{A0}}$

$F_{A0} = v_0 C_{A0}$