UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIO-ENGINEERING TECHNOLOGY

FINAL EXAMINATION

OCTOBER 2025 SEMESTER

COURSE CODE	:	CPD22604
COURSE TITLE	:	REACTION ENGINEERING
PROGRAMME NAME	:	DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY
DATE	:	24 JANUARY 2026
TIME	:	9:00AM - 12:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Section A consist 25 MCQ or EMQ questions. Answer ALL questions.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 12 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 25 marks)

Answer ALL questions.

Please use the objective answer sheet provided.

1. The type of catalyst used in catalytic converters for gasoline-fueled vehicles.

   A. Porous

   B. Unsupported

   C. Molecular sieves

   D. Monolithic

2. The three ways a reactant can react to form a product are listed below, **EXCEPT**

   A. Triple site

   B. Dual site

   C. Single site

   D. Eley Rideal

3. The characteristics of a good catalyst are;

   I. large surface area
   II. porosity
   III. stability
   IV. selectivity

   A. I, II and III

   B. I and IV

   C. I and III

   D. I, III and IV

4. Select the type of catalyst used in the production of butadiene.

   A. Unsupported

   B. Supported

   C. Molecular Sieves

   D. Monolithic

5. Catalyst increases the rate of reaction as it _____.

   A. increases the activation energy.

   B. decreases the molecular collision diameter.

   C. decreases the energy barrier for the reaction.

   D. None of these.

6. Choose the type of catalyst that is commonly used in the petroleum reforming process.

   A. Molecular sieves

   B. Supported

   C. Monolithic

   D. Porous

7. The loss of catalytic activity due to crystal agglomeration and growth of the deposited metals is known as _____.

   A. sintering

   B. aging

   C. coking

   D. poisoning

8. Name the catalyst that can be derived from natural or synthetic substances.

   A. Molecular sieves

   B. Porous

   C. Supported

   D. Monolithic

9. The catalyst with many pores and a large surface area is known as _____.

   A. Supported

   B. Porous

   C. Monolithic

   D. Molecular sieve

10. Stability refers to a catalyst's ability to withstand deactivation caused by the following factors **EXCEPT**

    A. Attrition due to mechanical movement or pressure shock.

    B. Thermal deterioration, volatility and hydrolysis of active components.

    C. The presence of impurities in the feed.

    D. Being impregnated into a porous structure.

11. Deactivation of a catalyst by _____ occurs when the poisoning molecules become irreversibly chemisorbed to the active sites.

    A. coking

    B. aging

    C. sintering

    D. poisoning

12. State the catalyst that contains promoters as an active ingredient.

    A. Supported

    B. Porous

    C. Monolithic

    D. Unsupported

13. Name the catalyst that deposits on the cell walls or impregnates into a thin coating or other porous support.

    A. Porous

    B. Molecular sieves

    C. Monolithic

    D. Supported

14. This catalyst is frequently utilized in reactions where pressure drop and heat removal are critical factors.

    A. Molecular sieves

    B. Monolithic

    C. Supported

    D. Porous

15. At the end of the chemical reaction, the catalyst remains _____.

    A. changed in quantity and composition.

    B. unchanged in quantity and composition.

    C. unchanged in composition but changed in quantity.

    D. unchanged in quantity but changed in composition.

16. The loss of catalytic activity resulting from prolonged exposure to high gas phase temperatures is due to _____.

    A. aging

    B. sintering

    C. poisoning

    D. coking

17. The activation energy is defined as

    A. the energy that reacting molecules must possess for the reaction to occur.

    B. the energy produced from a chemical reaction.

    C. the maximum energy that reacting molecules must possess for the reaction to occur.

    D. the minimum energy that reacting molecules must possess for the reaction to occur.

18. The Eley-Rideal mechanism is defined as follows:

    A. The reaction between an adsorbed reactant and either an occupied or unoccupied site.

    B. The reaction of two species that are adsorbed on different types of sites.

    C. The reaction between two adsorbed species.

    D. The reaction between an adsorbed molecule and a molecule in the gas phase.

19. The selectivity of a good catalyst refers to _____.

    A. the ability to resist deactivation effects.

    B. the ability to promote the rate of desired reactions.

    C. the ability to simplify the reaction steps.

    D. the ability to promote the desired reaction rate while inhibiting undesired reactions.

20. The _____ process results from carbonaceous material depositing on a catalyst's surface.

    A. poisoning

    B. aging

    C. sintering

    D. coking

21. In a catalytic reaction, several steps must occur **EXCEPT** for

    A. desorption

    B. combination

    C. diffusion

    D. adsorption

22. The reaction occurring between different phases of a catalyst and reactants is called

    A. homogeneous reaction

    B. elementary reaction

    C. non-elementary reaction

    D. heterogeneous reaction

23. Name the catalyst that selectively allows small molecules to pass through its pores while blocking larger ones.

    A. Molecular sieve

    B. Porous

    C. Monolithic

    D. Supported

24. The catalyst used in the hydrogenation of vegetable oil is _____.

A. Nickel

B. Platinum

C. Ferum

D. Palladium

25. The decline in a catalyst's activity as time progresses is called _____.

A. absorption

B. adsorption

C. activation

D. deactivation

SECTION B (Total: 75 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

The gas-phase reaction is represented as follows

$$A \rightarrow B + C$$

The irreversible reaction is conducted isothermally at a temperature of 30°C and a total pressure of 10 atm. The mixture is fed at an initial rate of 10 dm^3/s. The inlet gas mixtures consist of 55 mol% inert gases. Using the data provided, calculate the individual reactor volumes and the total reactor volume for each scheme, given the intermediate conversion is 40% and the final conversion is 80%.

Refer Below - Table1 : The reaction rate data .

Table 1: The reaction rate data

X	$-r_A$ ($mol/dm^3.min$)
0.0	4.5
0.1	4.4
0.2	4.2
0.3	3.7
0.4	3.2
0.5	2.5
0.6	1.7
0.7	0. 20
0.8	0.17
0.85	0.001

(a) Scheme A: PFR - CSTR

(14 marks)

(b) Scheme B: CSTR - PFR

(8 marks)

(c) Scheme C: Single PFR

(3 marks)

Question 2

The following gas phase reaction is carried out isothermally at a temperature of 451.24K with no pressure drop.

$$A \rightarrow B + 2C$$

The activation energy for the reaction is 15,000 J/mol and the frequency factor is 0.485 L/mol.min. The initial concentration of pure A is 5.0 mol/L. The initial rate is 10.0 L/min. The reaction is second order with respect to reactant A.

(a) Calculate the volume of a Plug Flow Reactor (PFR) if 80% of reactant A is converted. (Please show Steps 1 to 4).

(14 marks)

(b) Calculate the volume of a Continuous Stirred Tank Reactor (CSTR) if the reaction conditions are the same as in Part (a).

(5 marks)

(c) If the above reaction is conducted in a batch reactor, determine the reaction time required for the reaction.

(6 marks)

Question 3

The liquid-phase reaction in a flow reactor at 150°C is given as

$$A + 2B \rightarrow 2C$$

The initial concentrations of A and B are 1.8 mol/dm^3 and 5.4 mol/dm^3, respectively, with an initial rate of 10 dm^3/min. Given a specific reaction rate constant of 1.7 dm^6/mol^2.min at 100°C and an activation energy of 5.0 kcal/mol. The reaction obeys the elementary rate law.

(a) Construct a stoichiometric table for the reaction. All values should be in the function of conversion, X only by numerically evaluating all other symbols (e.g., ε, θ).

(13 marks)

(b) Determine the rate of disappearance of A if the conversion is given as 80%.

(12 marks)

Question 4

The elementary irreversible liquid-phase isomerization reaction was conducted in a batch reactor at 50°C.

$$A \rightarrow 2B$$

The concentration-time data are presented in the table below.

Refer Below - Table2 : Concentration-time data .

Table 2: Concentration-time data

Time (min)	0	2.5	5	7.5	10	12.5	15	17.5
Concentration (mol/dm^3)	4.0	2.89	2.0	1.25	0.8	0.45	0.25	0.16

(a) Using an appropriate integral method, determine the reaction order and the rate constant for the above reaction.

(13 marks)

(b) Given the frequency factor as 200/min, calculate the activation energy (in J/mol) for the reaction.

(3 marks)

(c) Calculate the rate of formation of B at 15 minutes.

(6 marks)

(d) If the reaction is cooled to 300 K, determine the new rate constant for the reaction.

(3 marks)

END OF EXAMINATION PAPER

APPENDICES

A. LIST OF INTEGRALS

$$\int_0^X \frac{dX}{(1-X)} = \ln\left(\frac{1}{1-X}\right)$$

$$\int_{X1}^{X2} \frac{dX}{(1-X)^2} = \frac{1}{1-X_2} - \frac{1}{1-X_1}$$

$$\int_0^X \frac{dX}{(1-X)^2} = \frac{X}{1-X}$$

$$\int_0^X \frac{dX}{(1+\varepsilon X)} dX = \frac{1}{\varepsilon} ln\,(1+\varepsilon X)$$

$$\int_0^X \frac{(1+\varepsilon X)}{(1-X)} dX = (1+\varepsilon)\, ln\left(\frac{1}{1-X}\right) - \varepsilon X$$

$$\int_0^X \frac{(1+\varepsilon X)}{(1-X)^2} dX = \frac{(1+\varepsilon)X}{(1-X)} - \varepsilon\, ln\left(\frac{1}{1-X}\right)$$

$$\int_0^X \frac{(1+\varepsilon X)^2}{(1-X)^2} = 2\varepsilon(1+\varepsilon)ln(1-X) + \varepsilon^2 X + \frac{(1+\varepsilon)^2 X}{(1-X)}$$

$$\int_0^X \frac{dX}{(1-X)(\theta_B - X)} = \frac{1}{(\theta_B - 1)} ln \frac{(\theta_B - X)}{\theta_B(1-X)} \quad where\ \theta_B \neq 1$$

B. LIST OF FORMULATIONS

$$C_{A0} = \frac{y_{A0} P_0}{RT_0} \qquad C_{A0} = \frac{F_{A0}}{v_0}$$

$$k = Ae^{\left[\frac{-E_a}{RT}\right]} \qquad k_2 = k_1 e^{\left[\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]}$$

$$\frac{1}{C_A} = \frac{1}{C_{A0}} + kt \qquad \ln\left(\frac{C_{A0}}{C_A}\right) = kt \qquad C_A = C_{A0} - kt$$

$$t = N_{A0} \int_0^X \frac{dX}{-r_A V} \qquad V = \frac{F_{A0} X}{-r_A}$$

$$V = F_{A0} \int_0^X \frac{dX}{-r_A} = F_{A0}\left(\frac{\Delta X}{3}\right)\left(\frac{1}{-r_A(X_0)} + \frac{4}{-r_A(X_{mid})} + \frac{1}{-r_A(X)}\right)$$

$$\upsilon = \upsilon_0(1 + \varepsilon X)\left(\frac{P_0}{P}\right) \qquad \varepsilon = y_{A0}\delta$$

$$\tau = \frac{V}{\upsilon_0} \qquad SV = \frac{1}{\tau}$$

$$\ln t_{1/2} = \ln\frac{2^{\alpha-1}-1}{(\alpha-1)k} + (1-\alpha)\ln C_{A0}$$

$$\ln(-r_{A0}) = \alpha \ln C_{A0} + \ln k$$

$$\ln\left(-\frac{dC_A}{dt}\right) = \ln k + \alpha \ln C_A$$

Initial point: $$\left(\frac{dCA}{dt}\right)_{t_0} = \frac{-3C_{A0} + 4C_{A1} - C_{A2}}{2\Delta t}$$

Interior points: $$\left(\frac{dCA}{dt}\right)_{ti} = \frac{1}{2\Delta t}\left[\left(C_{A(i+1)} - C_{A(i-1)}\right)\right]$$

Last point: $$\left(\frac{dCA}{dt}\right)_{ti} = \frac{1}{2\Delta t}\left[\left(C_{A(i-2)} - 4C_{A(i-1)} + 3C_{Ai}\right)\right]$$

C. GAS CONSTANT

R = 8.314 kPa.dm^3/mol.K
= 0.082 atm.dm^3/mol.K
= 1.987 cal/mol.K
= 8.314 J/mol.K

D. FACTORS FOR UNIT CONVERSIONS

Quantity	Equivalent Values
Mass	1 kg = 1000 g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz
	1 lb_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 ($\overset{0}{A}$)
	= 39.37 in = 3.2808 ft = 1.0936 yd = 0.0006214 mile
	1 ft = 12 in = 1/3 yd = 0.3048 m = 30.48 cm
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
	1ft^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 lb_f
	1 lb_f = 32.174 lb_m.ft/s^2 = 4.4482 N = 4.4482 x 10^5 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
	= 14.696 lb_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 = 1 J/s = 0.23901 cal/s = 0.7376 ft.lb_f/s = 9.486 x 10^{-4} Btu/s
	= 1.341 x 10^{-3} hp
Temperature	T(°F) = 1.8 T(°C) + 32
	T(°R) = T(°F) + 459.69
	T(K) = T(°C) + 273.15
	T(°R) = 1.8 T(K)