Code: 6460

2023-2024
B. TECH (AUTUMN SEMESTER) EXAMINATION
(~~CHEMICAL~~ / PETRO-CHEMICAL ENGINEERING)
AMS-2410 (HIGHER MATHEMATICS)
Credits-04

Maximum Marks: 60 **Duration: Two Hours**

Answer all questions:

1(a) Find the values of the constants a, b, c so that the directional derivatives of $f = axy^2 + byz + cz^2x^3$ at (1, 2,-1) has a maximum magnitude 64 in the direction parallel to z-axis. **[CO-1]**

OR

(a') Find n such that $\vec{F} = \frac{\vec{r}}{r^n}$ is solenoidal, (where $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, $r = |\vec{r}|$).

(b) Show that the vector field $\vec{A}$, where $\vec{A} = (2xy + z^2)\hat{\imath} + (2yz + x^2)\hat{\jmath} + (2zx + y^2)\hat{k}$ is irrotational. Find scalar function f such that $\vec{A}$=grad f.

[8, 7]

2.(a) Show that $\vec{F} = (2xy + z^3)\hat{\imath} + x^2\hat{\jmath} + 3z^2x\hat{k}$ is a conservative field. Find its scalar potential and also the work done in moving a particle from the points $(1, -2, 1)$ to$(3, 1, 4)$. **[CO-2]**

(b) Use divergence theorem to evaluate the surface integral $\iint_S \vec{F}.\overrightarrow{ds}$, where $\vec{F} = x^3\hat{\imath} + x^2y\hat{\jmath} + x^2z\hat{k}$ and S is the surface of the sphere $x^2 + y^2 + z^2 = 1$

OR

(b') If $\vec{F} = y\hat{\imath} + (x - 2zx)\hat{\jmath} - xy\hat{k}$, evaluate $\iint_S (\nabla \times \vec{F}).\hat{N}\,\overrightarrow{ds}$, where S is the surface of the sphere $x^2 + y^2 + z^2 = a^2$, above the xy plane.

[8, 7]

Contd....2.

3.(a) If $f(z)$ is an analytic function of z, prove that [CO-3]

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)|f(z)|^2 = 4|f'(z)|^2.$$

OR

(a') If $f(z) = u + iv$ is an analytic function of z and $u + v = \frac{2Sin2x}{e^{2y}+e^{-2y}-2Cos2x}$, find $f(z)$ in terms of z.

(b) Use Cauchy's integral formula to evaluate

(i) $\int_C \frac{e^{3z}}{(z+1)^4}dz$, where C is a circle $|z| = 2$.

(ii) $\int_C \frac{z}{(z^2-6z+25)}dz$, where C: $|z-3-4i| = 4$.

[8, 7]

4.(a) Form the partial differential equations by eliminating the arbitrary constants and arbitrary function from the following relations: [CO-4]

(i) $z = ae^{-b^2t}cosbx$

(ii) $f(x^2+y^2,\ z-xy) = 0$

(b) Use the method of separation of variables, to solve the partial differential equation:

$$\frac{\partial^2 z}{\partial x^2} + 4\frac{\partial^2 z}{\partial y^2} = 0$$

OR

(b') A tightly stretched string with fixed end points $x = 0$ and $x = l$ is initially in a position given by $y(x, 0) = y_0 \sin(\frac{\pi x}{l})$. If it released from rest from this position, find the displacement y at any distance x from one end at any time t.

[7, 8]

2023-24

B.TECH. (AUTUMN SEMESTER) EXAMINATION

CHEMICAL/PETROCHEMICAL ENGINEERING/FOOD TECHNOLOGY

BASIC PRINCIPLES OF CHEMICAL ENGINEERING

CHC2010/ PKC2010/CHA2010

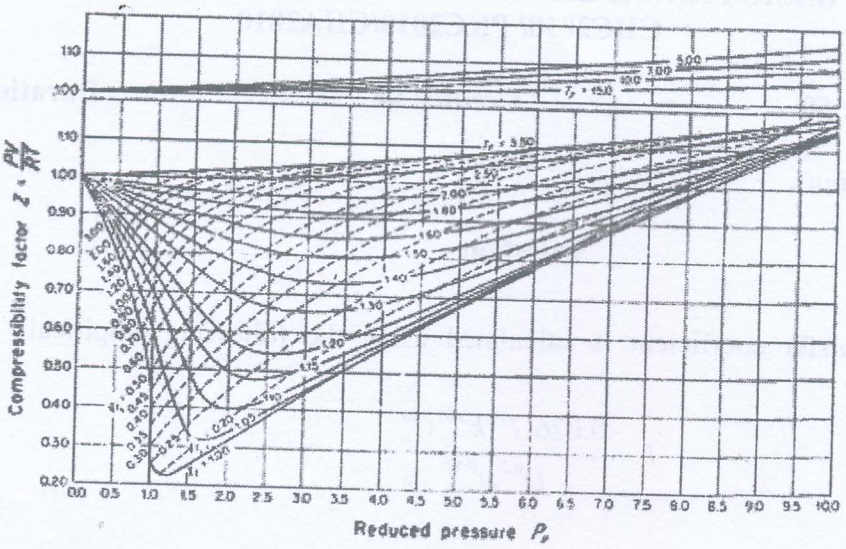
Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all the questions.

Q No	Question	Marks	CO covered
1(a)	The heat transfer coefficient is calculated using the following empirical equation. $$h = \frac{0.026 G^{0.8} k^{0.67} C_p^{0.5}}{D^{0.2} \mu^{0.47}}$$ where h is heat transfer coefficient in Btu/hr ft^2 °F; G is mass velocity of liquids in lb/ft^{2}s; k is thermal conductivity in Btu/ft.hr. °F; C_p is specific heat in Btu/lb °F; D is diameter of tube in ft; μ is viscosity of liquid in lb/ft s. what is the unit of the constant 0.026? Hence convert the equation into SI units.	[06]	CO-1
1(b)	Ammonia is oxidized to nitric oxide in the following reaction: $$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$ If 50.0 kg of ammonia and 100.0 kg of oxygen are fed to a batch reactor, determine the limiting reactant, the percentage by which the other reactant is in excess, and the extent of reaction and mass of NO produced (kg) if the reaction proceeds to completion.	[09]	CO-1
	OR		
1'(a)	An aqueous solution of K_2CO_3 is prepared by dissolving 43 kg K_2CO_3 in 100 kg water at 293 K. The density of the solution is 1.3 kg/L. Find the molarity, normality and molality of the solution.	[05]	CO-1
1'(b)	A gas contains 10.0 mole%, CO_2, 40.0 mole% CH_4, and 50.0 mole% C_2H_4. It is desired to distribute 14.2 kg of this gas per cylinder. Cylinders are to be designed so that the maximum pressure will not exceed 150 atm when the temperature is 80 °C. Using Kay's rule to calculate the volume of the cylinder required. The critical temperature and pressures of CO_2, CH_4, and	[10]	CO-1

Contd 2

C_2H_4 are 304.2 K and 72.9 atm; 190.7 K and 45.8 atm; and 283.1 K and 50.5 atm respectively.



2(a) Define a batch, a semi batch, and a continuous process. Write down the form of material balance for these processes. **[05]** **CO-2**

2(b) Fresh air containing 4.00 mole% water vapor is to be cooled and dehumidified to a water content of 1.70 mole% H_2O. A stream of fresh air is combined with a recycle stream of previously dehumidified air and passed through the cooler. The blended stream entering the unit contains 2.30 mole% H_2O. In the air conditioner, some of the water in the feed stream is condensed and removed as liquid. A fraction of the dehumidified air leaving the cooler is recycled and the remainder is delivered to a room. Taking 100 mol of dehumidified air delivered to the room as a basis of calculation, calculate the moles of fresh feed, moles of water condensed, and moles of dehumidified air recycled **[10]** **CO-3**

OR

2(b') Pure propane is burnt in an excess of air to give the following analysis of combustion products in volume percent: CO_2 – 5%, CO – 3.5%, H_2O – 11.4%, O_2 – 7%, N_2 – 73.1%. Calculate the composition of the flue gas on dry basis and the percentage excess air. **[10]** **CO-3**

3(a) A turbine discharges 200 kg/h of saturated steam at 10.0 bar absolute. It is desired to generate steam at 250°C and 10.0 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 10.0 bar. The enthalpy of saturated steam at 10 bar is 2776.2 kJ/kg and the enthalpy of superheated steam at 10 bar and 250 °C and 300 °C is 2443 kJ/kg and 3052 kJ/kg respectively. **[06]** **CO-2**

Contd .... 3.

(a) If 300 kg/h of the product steam is to be generated, how much heat must be added to the mixer?

(b) If instead the mixing is carried out adiabatically, at what rate is the product steam generated?

OR

3(a') Calculate the heat of vaporization of water (kJ/mol) at 50 °C and low pressure using the following information. **[06]** **CO-2**

Heat of vaporization of water at its normal boiling point: 40.656 kJ/mol

Heat capacity of liquid water: 75.4×10^{-3} kJ/mol·°C

Enthalpy of water vapor at 100 °C relative to 25 °C: 2.54 kJ/mol

Show clearly the process path selected for the calculation.

3(b) Define combustion reaction. How is the heat of combustion of the species in a reaction used to calculate the heat of reaction? Calculate the standard heat of the acetylene hydrogenation reaction **[09]** **CO-3**

$$C_2H_2\,(g) + 2H_2\,(g) \rightarrow C_2H_6\,(g)$$

using the following standard heat of combustion data

C_2H_2: −1299.6 kJ/mol; H_2: −285.84 kJ/mol; C_2H_6: −1559.9 kJ/mol

4(a) Water is added at varying rates to a 300-liter holding tank. When a valve in a discharge line is opened, water flows out at a rate proportional to the height and hence to the volume V of water in the tank. The flow of water into the tank is slowly increased and the level rises in consequence, until at a steady input rate of 60.0 L/min the level just reaches the top but does not spill over. The input rate is then abruptly decreased to 40.0 L/min. Write a differential balance on the water in the tank for the period from the moment the input rate is decreased and integrate the balance equation to derive an expression for $V(t)$. Calculate the time in minutes required for the volume to decrease to within 1% of its steady-state value. **[08]** **CO-3**

4(b) An air conditioner cools 226 m^3/min of humid air at 30°C and 90% relative humidity to 10 °C. Calculate the rate of condensation of water in the unit and the cooling duty. **[07]** **CO-4**

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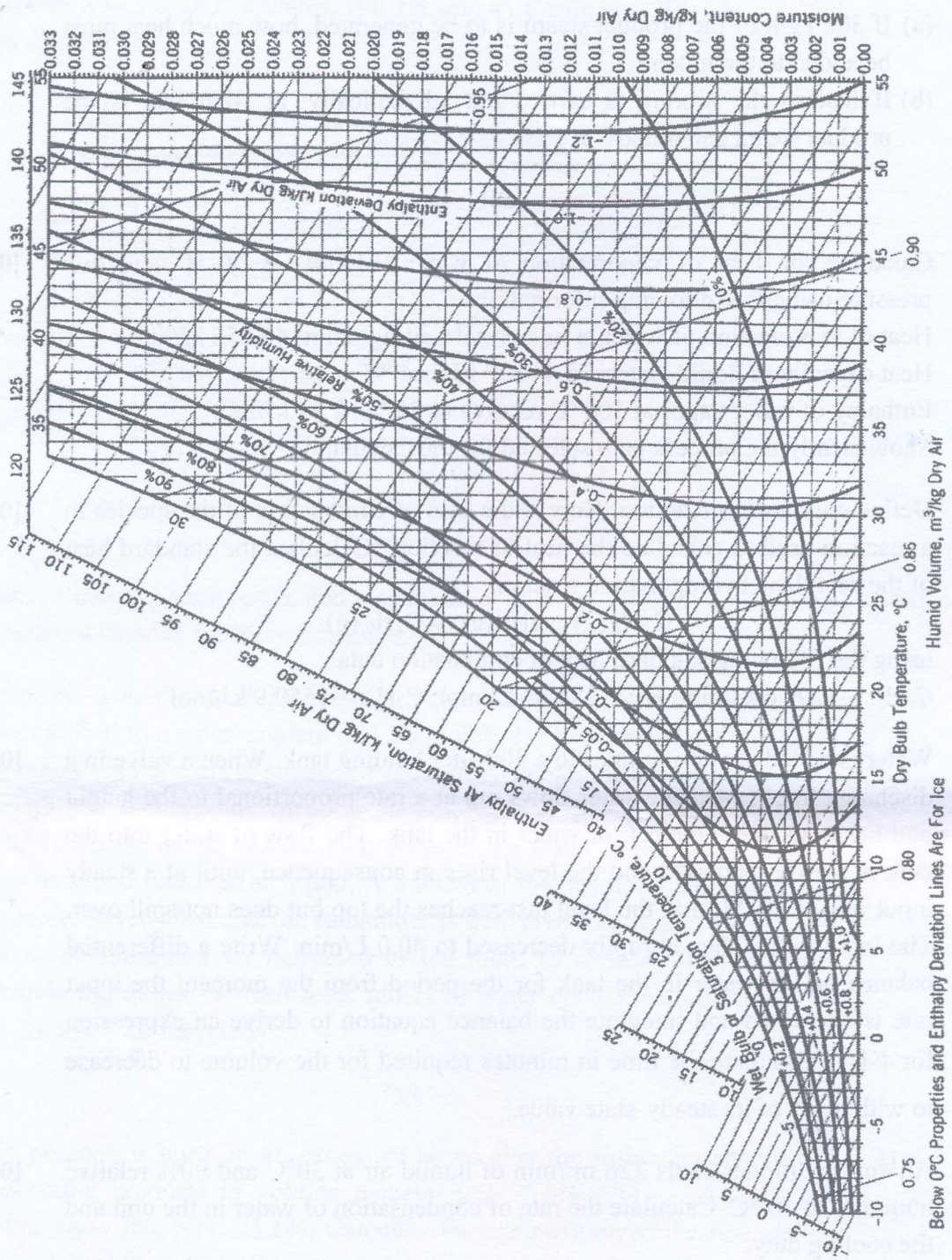
Contd.... 4.



Psychrometric Chart, Ref: H_2O (l, 0 °C, 1atm); Dry Air (0 °C, 1atm)

2023-2024

III SEMESTER B.TECH. (ODD SEMESTER) EXAMINATION

Petrochemical Engineering

Chemistry of Hydrocarbons

COURSE CODE: PKC 2030

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.	Question	M.M	
1(a)	Which year is generally taken as the starting point of modern petroleum industry? Write the name of any five important oil fields of our country.	[7]	(CO1)
	OR		
1(a')	What are the basic differences between asphaltenes and resins? What are the steps of crude oil formation?	[7]	(CO1)
1(b)	Write brief notes on the following : i) Reserves of crude oil ii) heavy and extra heavy crude oil	[8]	(CO1)
	OR		
(b')	What is the importance and significance of K_{UOP} and BMCI? How these are calculated? Which method do you feel convenient and superior?	[8]	(CO1)
2(a)	What are the non-hydrocarbon constituents of crude oil? Give briefly the names of various nitrogen and oxygen compounds present in the crude oil.	[6]	(CO2)
2(b)	Name any three international benchmark crudes. What is their importance in crude oil business?	[4]	(CO2)
2(c)	What do you mean by a theoretical plate? What are the different steps involved in creating a TBP curve?	[5]	(CO2)
	OR		

Contd....2.

2(c')	How does flash vaporization technique work? Draw ASTM, TBP and EFV curves.	[5]	(CO2)
3(a)	Briefly describe the process of electric desalting with the help of a neat sketch.	[5]	(CO3)
3(b)	How does a prefractionator help the refiner to increase the crude throughput? Why stripping is important?	[5]	(CO3)
3 (c)	Why LPG is considered as premium fuel? Write a note on the critical performance parameters of LPG. What are its commercial and domestic uses?	[5]	(CO3)

OR

3(c')	Write brief notes on **any one** of the following: i. Additives for motor gasoline ii. Rubberised bitumen iii. High Speed Diesel	[5]	(CO3)
4(a)	What are the important feed stocks for the production of petrochemicals? Why ethylene and propylene are considered as building blocks for the petrochemical Industry?	[5]	(CO4)
4(b)	What is the importance of alkylation process? Give the mechanism behind alkylation reactions.	[5]	(CO4)

OR

4(b')	Why is it important that the nitration of benzene by nitric acid occurs in sulfuric acid? Write mechanism for the sulfonation of benzene.	[5]	(CO4)
4(c)	What are the advantages of catalytic cracking over thermal cracking? Briefly describe the mechanism behind catalytic cracking reactions.	[5]	(CO4)

2023-24

B. TECH. (ODD SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING
REACTION KINETICS AND REACTOR DESIGN
PKC-2070

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all questions.
Assume suitable data if missing.
Notations and symbols used have their usual meaning.
Use of Graph paper is allowed.

Q.No.	Question	CO	M.M.
1(a)	Answer the following:	(CO1)	[2 x 4 = 08]
	(i) The statement "Rate of reaction ($-r_A$) is always equal to $-\frac{dC_A}{dt}$" is **TRUE** or **FALSE.** Justify your answer.		
	(ii) For a reaction $2A + 0.5B \leftrightarrow C$, if $C_{AO} = 4$ M, $C_{BO} = 2$ M, $-r_A = 3$ M.s^{-1} and $X_A = 0.8$ then calculate r_C and X_B.		
	(iii) Briefly explain the importance of Pseudo Steady State Hypothesis (PSSH) in search of reaction mechanism.		
	(iv) At 1100 K, n-nonane thermally decomposed 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition.		
1(b)	Show that the reaction scheme given below is consistent and can explain the 1st – order decomposition rate of N_2O_5.	(CO1)	[06]

$$N_2O_5 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} NO_2 + NO_3^*$$

$$NO_3^* \xrightarrow{k_3} NO^* + O_2$$

$$NO^* + NO_3^* \xrightarrow{k_4} 2NO_2$$

OR

1(b')	Describe the collision theory for the predictability of reaction rate and compare with Transition State Theory.	(CO1)	[06]

Contd....2.

2(a) Answer the following: (CO2) [2 x 2 = 04]

(i) For a liquid phase reaction A + 2B → C, if C_{A0} = 10 mol.L^{-1} and C_{B0} = 17 mol.L^{-1} are inlet concentration then which one is the limiting reactant and why?

(ii) Briefly describe an IDEAL Batch Reactor.

2(b) $A + 2B \rightarrow 3D$ & $-r_A = kP_AP_B^2$ (CO2) [05]

This gas phase reaction carried out in a 1 L batch reactor with N_{A0} = 2 mol and N_{B0} = 4 mol. Derive the expression for the conversion of A (X_A) with respect to time.

2(c) Reaction **A → Products** was carried out in a batch reactor. Kinetic data presented in the Table below. Find a rate equation using differential method to represent the data. (CO2) [05]

Time, sec	0	20	40	60	120	180	300
C_A, mol.L^{-1}	10	8	6	5	3	2	1

OR

2(c') Kinetics data of a reaction **A → products** (in constant volume batch reactor) given in the Table below. Derive a general expression for the fractional method used for rate law determination. Use the fractional method with F = 80% to determine order of reaction and rate constant. (CO2) [05]

C_{A0}	$C_{A\,end}$ $(=0.8C_{A0})$	Time needed t_F, s
10	8	0 → 18.5 = 18.5
5	4	59 → 82 = 23
2	1.6	180 → 215 = 35

3(a) Answer the following: (CO3) [01 + 02 = 03]

(i) The design equation for a batch reactor is given as $ktC_{AO} = \frac{C_{AO}-C_A}{C_A}$. Write the design equation for a PFR, if the same reaction carried out in PFR.

(ii) Derive the design equation for a CSTR operating at steady state, if $-r_A = k$.

3(b) For an elementary gas phase reaction A → 2R, the rate of reaction $-r_A = 0.1C_A$. What will be the ratio of volume of CSTR to PFR for a conversion of A (X_A) of 50% if the volumetric flow rate is 100 L/min and C_{AO} = 10 gmol/L. (CO3) [06]

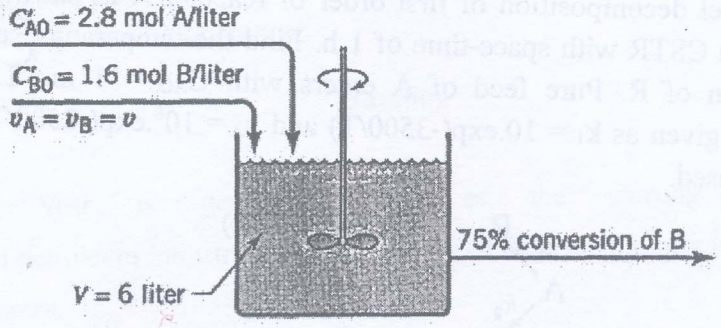
Contd ... 3.

OR

3(b') The elementary liquid-phase reaction $A + 2B \leftrightarrow R$ with (CO3) [06]

$$-r_A = (12.5 \text{ liter}^2/\text{mol}^2\text{-min})C_A C_B^2 - (1.5 \text{ min}^{-1})C_R$$

is to take place in the reactor shown below. Calculate the volumetric flow rate of inlet and outlet streams.



3(c) Reactor system of a CSTR followed by a PFR in series was used for reaction A → R. C_{AO} = 1 mol/L entered to CSTR then calculate the C_A exit after PFR, if $-r_A = 2C_A$, Space-Time$_{CSTR}$ = 1 h and Space-Time$_{PFR}$ = 2 h. (CO3) [05]

4(a) Answer the following: (CO4) [2 x 3 = 06]

(i) Differentiate between the complex multiple reactions and independent multiple reactions.

(ii) Define instantaneous selectivity and instantaneous yield.

(iii) The statement "For a reaction in CSTR, instantaneous selectivity and overall selectivity are equal" is **True** or **False.** Justify your answer.

4(b) The desired liquid-phase reaction (CO4) [06]

$$A + B \xrightarrow{k_1} R + T \qquad \frac{dC_R}{dt} = \frac{dC_T}{dt} = k_1 C_A^{1.5} C_B^{0.3}$$

is accompanied by the unwanted side reaction.

$$A + B \xrightarrow{k_2} S + U \qquad \frac{dC_S}{dt} = \frac{dC_U}{dt} = k_2 C_A^{0.5} C_B^{1.8}$$

From the standpoint of favourable product distribution, arrange the four contacting schemes shown in the Figure below, from the most desirable to the least desirable and justify your arrangement with the proper reasoning.

Contd....4.

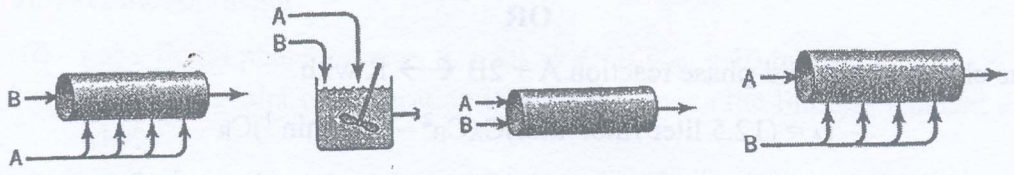
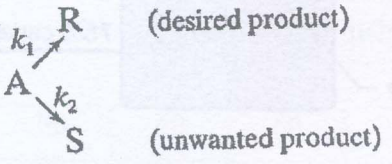


Figure. Various contacting schemes

(CO4) (CO5)

4(c) For the parallel decomposition of first order of reactant A as shown below is occurring in a CSTR with space-time of 1 h. Find the temperature which maximizes the production of R. Pure feed of A enters with C_{AO} = 1 mol/L and rate constants are given as $k_1 = 10.\exp(-3500/T)$ and $k_2 = 10^8.\exp(-8500/T)$. Derive the equation used. [06]



OR

(CO4) (CO5)

4(c') A reversible liquid phase reaction **A ←→ B,** is to be carried out in a CSTR to achieve 60% conversion of A. Calculate the optimum temperature to be maintaine and the optimum volume of the reactor. If the feed is pure A (C_{AO} = 10 mole/L) and the volumetric flow rate is 100 L/min. [06]

Given: $k_{forward} = 10.\exp(-3000/T)$ min^{-1} and $k_{backward} = 10^5.\exp(-6500/T)$ min^{-1}.

Code No. 6626

2023-24

B.TECH. (ODD SEMESTER) EXAMINATION

PETROCHEMICAL ENGINEERING / CHEMICAL ENGINEERING / FOOD TECHNOLOGY

FLUID- PARTICLE OPERATIONS / MECHANICAL OPERATIONS IN FOOD INDUSTRY

PKC – 2090 / CHC – 2040 / FTC – 2010

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all questions
Assume suitable data if missing
Notations and symbols used have their usual meaning
Use of Graph paper is allowed

Q.No.	Questions	CO	M.M
1(a)	Answer the following: (i) Discuss the significance of sphericity. (ii) Find out the sphericity, shape factor, and volume shape factor of a cylinder having geometry h=3D and assume its diameter as equivalent diameter?	(CO1)	[07]
1(b)	Data on screening operation is presented in below table. Particle size distributions of feed, overflow, and underflow are given as cumulative frequency. The screen used for separation has an aperture size of 460 μm and 1000 kg/h of feed are processed obtaining 650 kg/h of overflow. Calculate efficiency of the operation.	(CO1)	[08]

Table 1

Mesh	D_p (mm)	Cumulative Fraction		
		Feed	Coarse	Fine
4	4.699	0	0	-
6	3.327	0.025	0.071	-
8	2.362	0.150	0.43	0
10	1.651	0.470	0.85	0.195
14	1.168	0.730	0.97	0.58
20	0.833	0.885	0.99	0.83
28	0.589	0.940	1.00	0.91
35	0.417	0.960	-	0.94
65	0.208	0.980	-	0.975
Pan		1.00	-	1.00

Contd ....2.

1(b')	(i)	Explain with diagram the following bulk solid storage systems • Silos • Hoppers	(CO1) (CO1)	[05] [03]
	(ii)	Discuss the different flow patterns of solid from silo/hopper.		
2(a)	Discuss **ANY TWO:**		(CO2)	[2 × 2]
	(i)	Kick's Law with example.		
	(ii)	Work Index		
	(iii)	Crushing Efficiency and Mechanical Efficiency (in context of size reduction)		
2(b)	Define Bond's Law. Derive the equation for the work required to reduce the solid particle as per bond's law.		(CO2)	[05]
	OR			
2(b')	Discuss attrition mill and highlight its main industrial applications.		(CO2)	[05]
2(c)	Discuss the working principle of fluid energy mill with the help of suitable diagram.		(CO2)	[06]
3(a)	Differentiate between classification and jigging.		(CO3)	[03]
3(b)	Describe the working of the following:		(CO3)	[06]
	(i)	Hydro cyclone		
	(ii)	Disk Centrifuges		
	OR			
3(b')	With the help of proper diagrams, differentiate between axial and radial flow type of impellers for low viscosity liquids.		(CO3)	[06]
3(c)	Consider a rigid solid sphere falling with a constant velocity in a fluid. The following data are known at the condition of interest: viscosity of the fluid = 0.1 Pa.s, acceleration due to gravity = 10 ms^{-2}, density of the particle = 1180 kg m^{-3}, and density of the fluid = 1000 kg m^{-3}. Calculate the diameter (mm) of the largest sphere that settles in the stokes' law regime (Reynolds number ≤ 0.1).		(CO3)	[06]
4(a)	Discuss any two type of packing materials in packed bed.		(CO4)	[02]

Contd....-3.

4(b) Drive *Ergun's equation* for the pressure drop across the packing in packed bed column (CO4) [06]

OR

4(b') Drive the equation for the pressure drop across the incompressible filter cake. (CO4) [06]

4(c') A packed bed of solid particles of density 2000 kg/m^3, occupies a depth of 0.6 m in a cylinder vessel of inside diameter 0.1 m. The mass of solids in the bed is 5 kg and the surface volume mean diameter of the particles is 300 μm. A liquid of density 1000 kg/m^3 and viscosity 0.001 Pa.s flows upwards through the bed. (CO4) [07]

(i) What is the voidage of packed bed?

(ii) Determine the bed pressure drop when fluidized (Use force balance over the bed)

(iii) Determine the minimum fluidization velocity (Assume laminar flow and the voidage at incipient fluidization is the same as the packed bed).