Gandhi Institute of Engineering and Technology University, Odisha, Gunupur (GIET University)

M. Tech. (Third Semester - Regular) Examinations, December – 2025

24MCHPE23001 – Membrane Technologies for Water and Wastewater Treatment

(Chemical Engineering)

Time: 2 hrs | Maximum: 60 Marks

Answer ALL questions

(The figures in the right hand margin indicate marks)

PART – A (2 x 5 = 10 Marks)

Q.1. Answer ***ALL*** questions

	Question	CO #	Blooms Level
a.	Define osmotic pressure and state its relationship with solute concentration.	CO1	K3
b.	Differentiate between observed retention and real retention in membrane separation processes, explaining the basis of each.	CO2	K2
c.	Using a labelled diagram, draw and explain a typical molecular weight cut-off (MWCO) curve of a membrane.	CO4	K2
d.	Draw and compare sharp and diffused molecular cut-off curves of membranes, analyzing the structural reasons for the differences.	CO3	K1
e.	Define membrane permeability and evaluate its significance in determining overall membrane performance.	CO6	K2

PART – B (10 x 5 = 50 Marks)

Answer ***ALL*** the questions

	Question	Marks	CO #	Blooms Level
2. a.	Explain the significance of membrane modules in advanced separation processes and analyze how they contribute to improved operational efficiency.	5	CO1	K1
b.	Compare and evaluate the working mechanisms, design features, and performance characteristics of the following membrane modules—(i) plate-and-frame, (ii) hollow fiber, (iii) spiral wound, and (iv) tubular—and assess how each achieves high membrane area within a compact volume to enhance permeate flux	5	CO1	K2
	(OR)			
c.	Identify the various driving forces responsible for species transport in membrane operations and explain their roles in determining separation performance.	5	CO1	K2
d.	Using phenomenological equations, interpret and analyze the transport processes that govern the movement of species through membranes.	5	CO1	K2
3.a.	Develop the solution–diffusion model for RO/NF by incorporating solute flux through the membrane under realistic operating conditions. Clearly state the assumptions and derive the governing equations.	5	CO2	K3
b.	Critically examine and demonstrate the Modified Solution–Diffusion Model for RO/NF, explaining how it improves upon the classical formulation in predicting solute transport.	5	CO3	K4
	(OR)			
c.	Construct the Kedem–Katchalsky formulation for Ultrafiltration by introducing a reflection coefficient to represent imperfect solute retention, and derive the coupled flux equations	5	CO3	K3

d.	Illustrate and explain the Modified Solution–Diffusion Model for Ultrafiltration, emphasizing how the model accounts for solute–solvent interactions during membrane transport	5	CO2	K4
4.a.	Analyze the two fundamental geometrical configurations used in synthetic membrane fabrication, explaining how each geometry influences membrane performance and application suitability	5	CO2	K2
b.	Apply your understanding of membrane formation to outline and explain the sequential steps involved in the phase inversion technique for preparing integrally skinned asymmetric membranes, highlighting the role of each step in defining final membrane properties	5	CO2	K3
	(OR)			
c.	Evaluate the major steps involved in composite membrane preparation and assess how each step contributes to achieving selective transport and structural integrity	5	CO3	K4
d.	Design a suitable membrane surface-modification strategy aimed at minimizing contaminant deposition and sustaining high permeate flux, justifying the selection of chemical or physical modification methods.	5	CO3	K2
5.a.	Explain the Resistance Model used to describe solvent flux behaviour in Ultrafiltration, identifying the different resistance components involved.	5	CO3	K2
b.	Explain the Gel Polarization Model of Ultrafiltration and show how it can be applied to predict changes in solvent flux under varying solute concentration conditions.	5	CO4	K3
	(OR)			
c.	Analyze the fundamental principles of Nanofiltration, emphasizing how membrane structure, charge, and selective permeability influence solute–solvent transport.	5	CO4	K2
d.	Evaluate the industrial applications of Nanofiltration—particularly in water treatment, pharmaceuticals, and food processing—by assessing its operational advantages and limitations in each sector.	5	CO4	K3
6.a.	Explain the structural features and operational principles of membranes used in gas and vapor separation, and analyze how these properties influence selectivity and permeability.	5	CO5	K4
b.	Differentiate pervaporation and membrane distillation from other membrane processes by describing how phase change (liquid → vapor) governs their transport mechanism, and illustrate situations where this distinction affects process performance.	5	CO5	K3
	(OR)			
c.	Describe the ion-exchange mechanism occurring in electrodialysis membranes and analyze how membrane charge, structure, and applied electric field govern directional ion transport.	5	CO6	K3
d.	Examine major industrial and environmental applications of electrodialysis, and evaluate its effectiveness compared to alternative separation technologies in sectors such as water desalination, wastewater treatment, and chemical manufacturing.	5	CO6	K2

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