Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: Novel Separation Processes **Semester: 8**
Program: CE+RP **Time 03 hrs.**
Course Code: CHCE324 **Max. Marks: 100**

Instructions:

SECTION A

S. No.		Marks	CO
Q 1	Define Molecular Weight Cut-Off (MWCO) of a membrane.	**4**	**CO2**
Q 2	How do you experimentally obtain the two parameters of a membrane, real retention and membrane permeability?	**4**	**CO2**
Q 3	How are the spiral wound membrane and the tubular membrane modeled while deriving the design equations?	**4**	**CO3**
Q 4	How can the efficiency of a dialyzer unit be enhanced?	**4**	**CO4**
Q 5	Derive an expression for the flux, J, for the case of low concentration polarization and perfect retention. Assume a linear relationship between osmotic pressure and concentration.	**4**	**CO3**
	SECTION B		
Q 6	Derive an expression for the solvent flux for the case of gel layer formation with the real retention of the membrane less than unity. Your answer must be in terms of the film mass transfer coefficient , k, the ratio of the gel layer to the feed concentration (C_g/C_0) and the real retention R_r.	**10**	**CO3**
Q 7	Derive an expression for the fractional permeate recovery in case of a spiral wound membrane module with length L, width, w, distance between the two walls equal to $2h$, and membrane permeability, L_p. Assume that the permeate flux is proportional to the transmembrane pressure drop, and that the transmembrane pressure drop and the mass flow rate through the feed side at the entrance of the module are ΔP_i and Q_i respectively.	**10**	**CO3**
Q 8	A countercurrent dialyzer is using an experimental membrane to remove urea from an aqueous feed. The entering feed contains 10 g/L of urea and outlet should be 1 g/ L. Feed rate is 1 L/min. Inlet dialyzer is pure water and flow rate is 3 L/min. a. Determine the overall transfer rate in g/min. b. Determine the required value of k_TA where k_T is the mass transfer coefficient and A is the total membrane area.	**10**	**CO4**
Q 9	Derive an expression for the efficiency of a counter-current continuous dialyzer unit with feed rate Q_F, dialysate rate, Q_D, inlet feed concentration C_{Fi}, outlet feed concentration C_{Fo}, inlet dialysate concentration, C_{Di}, and outlet dialysate concentration, C_{Do}.	**10**	**CO4**

SECTION-C			
Q 10	A RO membrane is being used to produce a waste stream of 8% Na_2CO_3 solution by weight. The pure water flux is measured at $J^0 = 2000$ L/m^2 when $\Delta P = 0.01$ bar. With the same Na_2CO_3 solution, a process operation is performed at $P_{feed} = 0.05$ bar and $P_{permeate} = 0.001$ bar at a temperature of 30°C. Both permeate and feed are assumed to be perfectly mixed. a) For an ideal membrane ($R_r = 1.0$) find J when the polarization modulus is $M = 1$ and $M = 1.5$ b) For a real membrane, we measure $C_P = 0.0025$ g/cc when $M = 1.0$. Find J when $M = 1$ and $M = 1.35$. Assume that the linear relationship, $\Pi = b_1 C$ (1) where $b_1 = 500$ atm cc/g, holds between the osmotic pressure, Π and the concentration, C. Also, assume that the solute flux can be modeled using the solution diffusion model.	**20**	**CO3**
Q 11	Blood plasma proteins are known to gel at a concentration $Cg = 0.2$ weight fraction. With pure water a cellulose acetate membrane has a flux of 2.5×10^{-5} m^3/m^2.sec at a transmembrane pressure drop of 68.96 kPa. At an operating pressure drop of 103.44 kPa with the plasma solution, the flux is 0.416×10^{-5} m^3/m^2.sec. a. What is the gel layer resistance at steady state? b. If pressure drop is doubled, estimate the gel layer resistance again at steady state?	**20**	**CO3**

Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: Novel Separation Processes **Semester: 8**
Program: CE+RP **Time 03 hrs.**
Course Code: CHCE324 **Max. Marks: 100**

Instructions:

SECTION A

S. No.		Marks	CO
Q 1	What are the different driving forces for transport in a membrane?	**4**	**CO2**
Q 2	Derive an expression for the total mass transfer coefficient across a dialyzer membrane.	**4**	**CO4**
Q 3	How is the solution diffusion imperfection model an advancement of the solution diffusion model?	**4**	**CO3**
Q 4	In what way is dialysis different from reverse osmosis and ultrafiltration?	**4**	**CO4**
Q 5	Classify the following separation processes as rate controlled or equilibrium controlled. a. Distillation b. Chromatography c. Drying d. Dialysis	**4**	**CO1**

SECTION B

Q 6	Derive an expression for the dialysate concentration as a function of time for a well-mixed batch dialyzer unit. The mass transfer coefficient across the membrane is given by k, and the initial concentration of feed is given by C_F^0. The volumes of the feed and dialyzer solutions are V_F and V_D respectively.	**10**	**CO4**
Q 7	We wish to ultrafilter a 2 weight percent aqueous solution of albumin at 25°C.The albumin gels at $C_g = 0.12$ weight fraction. We perform two experiments as follows. Experiment a: Ran pure water and obtained $J_{solv} = 6000$ L/m^2.day with $\Delta p = 6$ atm. Experiment b: Ran albumin solution at $\Delta p = 6$ atm with $J_{solv} = 267$ L/m^2.day, $R_r = 1$. Calculate the film mass transfer coefficient k and the gel layer resistance μR_g for Experiment b.	**10**	**CO3**
Q 8	A co-current dialyzer is using an experimental membrane to remove ammonia from an aqueous feed. The entering feed contains 16.5 g/L of urea and outlet should be 0.5 g/L. Feed rate is 1 L/min. Inlet dialyzer is pure water and flow rate is 60 L/min. Determine the overall transfer rate in g/min. Determine the required value of k_TA where k_T is the mass transfer coefficient and A is the total membrane area.	**10**	**CO4**
Q 9	We are ultra-filtering a flexible chain polymer. In a stirred cell with no concentration polymerization $R_r = 0.996$ and $L_p = 2000$ L/m^2.day.atm. In a hollow fiber system, gelling occurs at $C_g = 80$ g/L and the gel appears to be completely mobile. In an experiment in the hollow fiber set-up where gelling occurs at $C_0 = 26$ g/L and $\Delta p = 6$ atm, we find that $J_{solv} = 82.83$ L/m^2.day. a. In the stirred cell, find J_{solv} and J_{solute} if $\Delta p = 5$ atm and $C_0 = 20$ g/L. b. In the hollow fiber system, find J_{solv}, R_0 and J_{solute} if $\Delta p = 5$ atm and $C_0 = 20$	**10**	**CO3**

	g/L.		
SECTION-C			
Q 10	Derive an expression for the efficiency of a co-current continuous dialyzer unit with feed rate Q_F, dialysate rate, Q_D, inlet feed concentration C_{Fi}, outlet feed concentration C_{Fo}, inlet dialysate concentration, C_{Di}, and outlet dialysate concentration, C_{Do}.	**20**	**CO4**
Q 11	Derive the quadratic expression for the solvent flux with $R_r < 1.0$ for the case of low concentration polarization ($J/k << 1$). Assume a linear relationship between osmotic pressure and the concentration of the solution.	**20**	**CO3**