BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : VI**
BRANCH: CHEMICAL ENGINEERING **SESSION : SP/19**

SUBJECT: CL6005 MODERN SEPARATION PROCESSES

TIME: 3:00 HOURS **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Explain the differences between adsorption and gas-solid chromatography. [2]

Q.1(b) Describe templet leaching method for the synthesis of porous isotropic polymeric membrane. [4]

Q.1(c) An open tank, 3 m in diameter and containing benzene at 25°C, is exposed to air in such a manner that the surface of the liquid is covered with a stagnant air film estimated to be 0.5 cm thick. If the total pressure is 1 atm and the air temperature is 25°C, what loss of material in kg per day occurs from this tank? The specific gravity of benzene is 0.877. The concentration of benzene at the outside of the film is so low that it may be neglected. For benzene, the vapor pressure at 25°C is 100 torr, and the diffusivity in air is 0.08 cm^2/s [6]

Q.2(a) A hollow-fiber module has 4,000 ft^2 of membrane surface area based on the inside diameter of the fibers, which are 42 μm i.d. × 85 μm 0.d. × 1.2 m long each. Determine:
(i) The number of hollow fibers in the module.
(ii) The diameter of the module, assuming the fibers are on a square spacing of 120 μm center-to-center. [2]

Q.2(b) It is desired to pass water at 70°F through a supported, polypropylene membrane, with a skin of 0.003 cm thickness and 35% porosity, at the rate of 200 m^3/m^2-day. The pores can be considered as straight cylinders of uniform diameter equal to 0.2 micron. If the pressure on the downstream side of the membrane is 150 kPa, estimate the required pressure on the upstream side of the membrane. The pressure drop through the support is negligible. The viscosity of water is 0.001 Pa.s. [4]

Q.2(c) Estimate membrane area and electrical-energy requirements for an electrodialysis process to reduce the salt (NaCl) content of 24,000 m^3/day of brackish water from 1,500 mg/L to 300 mg/L with a 50% conversion. Assume each membrane has a surface area of 0.5 m^2 and each stack contains 300 cell pairs. A reasonable current density is 5 mA/cm^2 and the current efficiency is 0.8 (80%). [6]

Q.3(a) Define electrophoretic mobility. Derive an expression for electrophoretic mobility in free solution. [4]

Q.3(b) A protein solution in 0.15(M) NaCl is ultra-filtered at 300 K with mass transfer coefficient 2×10^{-5} m/s. Filtration is gel layer controlled. Feed concentration is 10 kg/m^3 and gel concentration is 300 kg/m^3. The charge number on protein is 10e and it has a radius 5 nm. [8]

(i) What will be the permeate flux?
(ii) If an external electric field of 400 V/m is applied, what is the permeate flux?

Q.4(a) Write the name of the four physical methods for cell disruption. [2]

Q.4(b) Define following: (i) Sedimentation coefficient, (ii) Partition coefficient [4]

Q.4(c) Write a short note on the following: (i) Preparative centrifuge, (ii) tubular bowl centrifuge, (iii) Ultracentifugation [6]

Q.5(a) Describe briefly about thin-layer chromatography. [2]

Q.5(b) A chromatographic column having a volume of 2.5 liters is found to have a mobile phase retention time of 2 minutes at a flow rate of 0.5 l/min. A pulse of a pharmaceutical protein was injected into the column along with the mobile phase and using appropriate techniques the concentration of bound protein and free protein at a particular slice of the column at a particular instant were found to be 0.73 g/l and 0.28 g/l respectively. Estimate the retention time of the solute at a flow rate of 2 l/min. [4]

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Q.5(c) The details of chromatograms of two different compounds A and B are given below, which were obtained by injecting pure samples of these substances into a 30 cm long column. In both experiments, the same mobile phase flow rate was used. We would like to separate A and B at the same mobile phase flow rate from a mixture containing the same amounts of these substances as used for obtaining the chromatograms. The mobile phase residence time is 2 minutes and the voidage fraction is 0.3. Calculate: [6]

(i) Theoretical plate height of the chromatographic column
(ii) Selectivity
(iii) Resolution

Component	Peak width (min)	(t)max (min)
A	4	5
B	8	10

where, (t)max: time at which maximum concentration reached

Q.6(a) Write MESH equations for multicomponent system for an equilibrium stage. [4]

Q.6(b) A liquid containing 50 mol% benzene (A), 25 mol% toluene (B), and 25 mol % o-xylene (C) is flashed-vaporized at 1 std atm pressure and 100 °C. Compute the amounts of liquid and vapor and their composition. (Given: vapor pressure in mm Hg at 100 °C for benzene = 1370, for toluene = 550, and for o-xylene = 200; use initial guess for $\Psi = 0.5$). [8]

Q.7(a) Write the applications of reactive distillation. [2]

Q.7(b) Draw T-x-y diagrams of minimum boiling azeotrope and maximum boiling azeotrope for pressure swing distillation at two different pressures. Also draw the corresponding distillation sequences. [4]

Q.7(c) Describe briefly the following enhance distillation techniques: (i) Extractive distillation, (ii) Salt distillation, (iii) supercritical-fluid extraction. [6]

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