Indian Institute of Technology Guwahati
Department of Biosciences and Bioengineering
End-Semester Examination (29.04.2024)
Transport Phenomenon in Bioprocesses (BT 208)
Answer ALL the questions

All the assumptions made should be explicitly defined with suitable justification

ALL the Question no(s) with respective answers should be written LEGIBLY

Duration: 3 hrs. **Total Marks: 100**

1. A mixture of 45 mole % n-hexane and 55 mole % n-heptane is subjected to continuous fraction in a tray column at 1 atm total pressure. The distillate contains 95% n-hexane and the residue contains 5% n-hexane. The feed is saturated liquid. A reflux ratio is 2.4 is used. The relative volatility of n-hexane in mixture is 2.34. a) Determine the number of ideal trays required **(Graphical Method)** b) Determine the number of ideal trays using **Fenske equation (Analytical Method)**. (20 marks)

2. Explain in detail, Assumptions and the method of estimation of number of stages by Mc Cabe - Thiele method. (10 marks)

3. The pressures at two sections of a horizontal pipe are 2.9436×10^4 N/m^2 and 5.8872×10^4 N/m^2 and the diameters are 7.5 cm, and 15 cm respectively. Determine the direction of flow if water flows at mass flow rate of 8.5 kg/sec. State your assumptions and density of water is 1000 kg/m^3. (Use Bernoulli's equation). (10 marks)

4. a) State the types of fluids with suitable examples that are not Newtonian by nature. In a neat diagram mark the relation between shear stress and velocity gradient. (10 marks)

b) Derive the Hagen-Poiseuille equation (Laminar flow, Circular pipe), highlighting the assumptions made. **(10 marks)**

$$N_{m+1} = \frac{\log\left(\frac{z_f(1-x_w)}{x_w(1-z_f)}\right)}{\log \alpha}$$

$$\frac{\Delta P\, d^4}{L\, 128\, \eta}$$

5. A heat exchanger heats 25,000 kg/hr of water entering at 30°C while cooling 20,000 kg/hr of water from 100°C to 80°C. Determine the area necessary for (i) Parallel flow arrangement (ii) Counter flow arrangement. Overall heat transfer coefficient and specific heat of water may be assumed as 1,600 W/m^{2}K and 4.184 KJ/ kg K. (10 marks)

6. Derive an expression for **Forced and Natural convective** heat transfer through a conduit using Dimensional analysis equation. (20 marks)

7. A plane brick wall, 25 cm thick, is faced with 5 cm thick concrete layer. If the temperature of the exposed brick face is 70°C and that of the concrete is 25°C, find out the heat lost per hour through a wall of 15 m x10 m. Also, determine the interface temperature. Thermal conductivity of the brick and concrete are 0.7 W/m.K and 0.95 W/m.K respectively. (10 marks)