INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Mid-Spring Semester 2019-20

Date of Examination: As per Timetable **Slot D Duration** 2 hrs **Full Marks: 30**
Subject No. : CH61012 **Subject: ADVANCED MASS TRANSFER**
Department/Center/School : Chemical Engineering
Specific charts, graph paper, log book etc. required: No
Special Instructions (if any) : Make proper assumptions wherever necessary

Q1. In an irreversible system, the entropy balance equation can be written as $\rho\frac{d\hat{S}}{dt} = -\nabla.J + \alpha$.

Here $\rho\frac{d\hat{S}}{dt}$ indicates entropy of accumulation, $-\nabla.J$ = entropy in – entropy out and α is entropy of production. Starting with the equation $d\hat{G} = d\hat{H} - Td\hat{S}$ derive an equation which relates the entropy of production to the mass/molar or volume average velocity of the desired i^{th} component in a multicomponent diffusion process of 1,2,3…*i*….n component system **(10 marks)**

Q2. What additional assumptions are needed in the above equation to estimate D_{ij} that has been mathematically generalized from Ficks law for binary systems **(5 marks)**

Q3. A feed mixture containing Solute 1, Solute 2, and the carrier in the ratio of 2:3:4, available at overall feed rate of 90 moles / hour is brought in equilibrium with a pure solvent, flowing at a rate of 10 moles / hour. Assume liquid-liquid equlibria with constant distribution coefficients at the given temperature and pressure as listed below.

Component	K_{Di} value
Solvent	4.20
Solute 1	1.75
Solute 2	0.74
Carrier	0.34

i) **Calculate** the composition and overall molar flow rate of extract.

ii) Repeat the above problem for two equilibrium-stage cross current extraction instead of single stage process. Feed flow rate and composition remain same as above. Consider solvent flow rate of 10 moles / hour in each stage. **Calculate** the compositions and overall molar flow rates of extract streams from the two stages.

Hint: For initial estimate of ψ, check whether the value of $f(\psi)$ is close to 0, as the value of ψ is systematically varied within the range from 0 to 1. You are expected to show one Newton Raphson iteration. **(10+5 =15 marks)**