INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Mid-Autumn Semester Examination 2023-24

Date of Examination: 20.09.2023 Session: AN Duration: 2 hrs Full Marks: 30

Subject No.: CH31010 Subject : Mass Transfer 2

Department/Center/School: Chemical Engineering

Specific charts, graph paper, log book etc., required: Graph Paper (2 per student)

Special Instructions (if any):

- *Please write answers in brief and to the point, with logical arguments. Avoid extended descriptions.*
- *Make suitable assumptions as necessary, and provide justifications for the same in case you think any data is missing. No doubts can be entertained during the examination*
- *Part marking to the solution of a question will be considered only when it is partially correct, not for partially incorrect / illogical attempts.*
- *Psychrometric chart and triangular graph papers will be necessary. They are attached with the question paper. Please ask for regular graph paper in the exam hall.*

Part A

Q1: In a process, benzene is evaporated into dry nitrogen. At 297 K and 101.3 kPa, the resulting mixture has a relative humidity of 60% (this is not percent humidity). The gas mixture is cooled to 283 K at same pressure (101.3 kPa). How much fraction of Benzene is removed?

The vapour pressure of benzene is 12.2 kPa at 297 K and 6 kPa at 283 K. You can assume ideal gas law for the calculations. [2]

Q2: In a continuous dehumidifier, air at 40 C and 80% humidity is dehumidified to 50% of the moisture content, thereby reducing the absolute humidity to half of its inlet value. The exit air is at its dew point. What is the heat load of the system for processing 0.5 Ton of dry air / hour. [2]

Q3: Warm water at 45 C is to be cooled to 30 C in a packed cooling tower. The ambient air has a dry-bulb temperature of 35 C and the designed approach is 10 K. The mass flow rate of water is 10 Ton/m^2.h and that of air is 4 ton/m^2. h. The heat transfer coefficient is very large. Calculate the height of the tower needed to achieve the desired cooling. The height of each transfer unit is 0.5 m. You can use the printed graph sheet for this question. [6]

Q4: What is the difference between adiabatic saturation temperature and wet bulb temperature? Under what conditions they are same. Explain with mathematical arguments. [2]

Q5: Explain the physical process and derive the Langmuir isotherm for single component and multi-component adsorption process. [3]

PART B:

6. The following equilibrium data is given.

x	Fraction of B	y	Fraction of B
0	0.12	0	0.87
0.02	0.11	0.04	0.86
0.05	0.10	0.10	0.80
0.10	0.09	0.17	0.73
0.15	0.08	0.27	0.62
0.21	0.06	0.32	0.53
0.29	0.08	0.43	0.36

a) Draw the phase diagram on the given triangular graph paper. Label the graph properly. (2)

b) 30 Kg of a recycled solvent with 5% A and 5% C is mixed with certain amount of feed in a **single stage** batch extractor, with initial solute concentration of 25%. The final Raffinate contains 16% solute. Calculate the amount of Feed used, and also the amounts of Extract and Raffinate produced. **(3)**

(Total Marks for Question 6: 05)

7. A feed with flow rate **82.5 Kg/hr** and solute concentration of **30%** is to be extracted with **30 Kg/Hr** pure solvent in a continuous counter current extractor. The desired solute concentration in the extract is **41%**. The equilibrium plot along with the tie line is attached. Graphically solve the problem.

Answer the following questions:

a) Draw the general flow-sheet for continuous counter current extractor and define what is Δ_R. (2)

b) Locate the point Δ_R and graphically find out the concertation of the solute in the raffiniate. Show the balances. (2+2)

c) Now, draw the equilibrium plot and the operating line on a x-y plot. At least 3 points must be taken for the operating line. (4)

(Total Marks for Question 7: 10)

All the best ☺