

Name :

Roll No. :

Invigilator's Signature :

CS/B.Tech (BT-NEW)/SEM-5/CHE-514/2010-11

2010-11

TRANSFER OPERATION – II

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

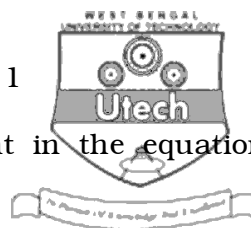
GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

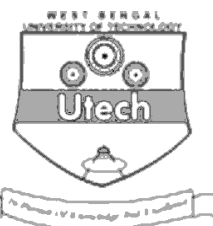
- i) The slope of operating line for the stripping section of distillation column is
 - a) 0
 - b) ∞
 - c) <1
 - d) >1 .
- ii) For a saturated vapour in distillation, q value is
 - a) 0
 - b) 1
 - c) $0 < q < 1$
 - d) ∞ .
- iii) For gas phase controlled mass transfer system
 - a) Gas phase provides entire resistance
 - b) Liquid phase provides entire resistance
 - c) Inter-phase provides entire resistance
 - d) Gas phase provides minimum resistance.



- iv) The unit of mass transfer coefficient in the equation $N_A = K_y(y - y^*)$ is
- a) $\text{kmol/m}^3/\text{hr}$ b) $\text{kg/m}^2/\text{Pa}$
c) $\text{kmol/m}^2/\text{hr}$ d) kg/m^2 .
- v) Mass diffusivity has the same unit of
- a) Thermal diffusivity b) Kinematic viscosity
c) Both (a) and (b) d) None of these.
- vi) Crystals can be formed by
- a) Increasing the temperature of the solution
b) Decreasing the temperature of the solution
c) Removing water from the solution
d) Both (b) and (c).
- vii) Leaching is
- a) Gas-Liquid mass transfer
b) Gas-Solid mass transfer
c) Liquid-Liquid mass transfer
d) Solid-Liquid mass transfer.
- viii) The dew point of an unsaturated mixture of vapour and gas does not depend on
- a) The temperature of the mixture
b) The total pressure of the mixture
c) The composition of the mixture
d) All of these.



- ix) At minimum reflux condition in a distillation column, the number of plates becomes
- Minimum
 - Infinite
 - More than that predicted by McCabe – Thiele method
 - Less than that predicted by McCabe – Thiele method.
- x) Rejection coefficient of an ultrafilter varies from
- 0.95 to 0.98
 - 0 to 0.5
 - 0.5 to 0.75
 - 0.85 to 0.92.
- xi) Osmotic pressure of a dilute solution is given by
- $\Pi = CRT(1 + B_1C + B_2C^2 + \dots)$
 - $\Pi = CR/T$
 - $\Pi = CT/R$
 - $\Pi = CRT$.
- xii) The driving force for filtration is
- Solid concentration difference between permeate and retentate
 - Filtrate pressure – Inlet pressure
 - Concentration polarization
 - None of these.



GROUP – B

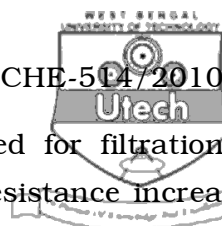
(Short Answer Type Questions)

Answer any *three* of the following.

3 × 5 = 15

2. What is batch distillation ? Derive the Rayleigh equation for simple distillation in a batch still with a sketch of the distillation unit.
2 + 3
3. A slab of paper pulp 100 cm × 100 cm × 1.5 cm is to be dried under constant drying condition from 66.7 to 30%. The value of equilibrium moisture to material is 0.5%. If critical moisture content is 60% and the rate of drying at critical point is 1.5 kg/hr m², calculate the drying time. The dry weight of each slab is 2.5 kg. All moisture contents are on wet basis.
5
4. How does the pressure varies within a packed bed absorption column ? Define flooding point, loading point, channelling in a packed bed column.
2 + 3
5. Explain the operation of fixed bed leaching and moving bed leaching and mention the industries where they are used.

$$2\frac{1}{2} + 2\frac{1}{2}$$



6. In a cross-flow ultrafiltration system used for filtration of proteins from a fermentation broth, gel resistance increases with protein concentration according to the following equation :

$$R_g = 0.5 + 0.01(C), \text{ where } C \text{ is in mg/L.}$$

Pressure at the entrance of the system is $P_i = 6$ atm and at the exit is $P_o = 2$ atm. The shell side of the filter is open to the atmosphere, resulting in $P_f = 1$ atm. The membrane resistance is $R_M = 0.5 \text{ atm}/(\text{mg}/\text{m}^2 \cdot \text{h})$, and protein concentration in the broth is $C = 100 \text{ mg/L}$. Determine :

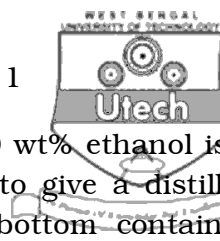
- the pressure drop across the membrane.
- filtration flux.
- rejection coefficient of the membrane for effluent protein concentration of $C_f = 5 \text{ mg/L}$.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

- Calculate the rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 2 mm at 17°C , when the concentration by weight on the opposite sides of the film are 10% and 4% acid. The diffusivity of acetic acid in the solution is $0.000095 \text{ m}^2/\text{s}$. Densities of 10% and 4% acid (by weight) are $1013 \text{ kg}/\text{m}^3$ and $1004 \text{ kg}/\text{m}^3$, respectively.
 - Explain the analogy between heat transfer, mass transfer and momentum transfer with respect to their flux equation. 10 + 5



8. a) A feed of ethanol-water containing 60 wt% ethanol is to be distilled at 101.32 kPa pressure to give a distillate containing 85 wt% ethanol and a bottom containing 2 wt% ethanol. The feed rate is 10,000 kg/hr and its enthalpy is 116.3 kJ/kg. Feed is saturated liquid at its boiling point.
- Calculate the amount of distillate and bottoms.
 - Determine the minimum reflux ratio.
 - Using 2.0 times the minimum reflux ratio, determine the theoretical number of trays needed.

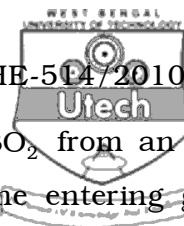
Equilibrium data for ethanol-water mixture :

<i>x</i>	0	0.02	0.05	0.1	0.2	0.3	0.5	0.7	0.8	0.9	0.96	1.0
<i>y</i>	0	0.192	0.377	0.527	0.656	0.713	0.771	0.822	0.858	0.912	0.959	1.0

- What are Murphree efficiency and the overall plate efficiency ?
12 + 3
9. a) A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 20% Na_2CO_3 is cooled to 293 K and crystal of $\text{Na}_2\text{CO}_3 \cdot 10 \text{ H}_2\text{O}$ is precipitated at 293 K, the solubility is 21.5 kg anhydrous/100 kg of total water. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling.
- 150 kg of a nicotine-water solution containing 1% moisture is to be extracted with 220 kg of kerosene at 20° C. Water and kerosene are immiscible in each other. Determine the percentage of extraction of Nicotine after one stage operation. At dilute end of the system the equilibrium relationship is

$$Y^* = 0.798X$$

where *Y* and *X* are expressed as kg nicotine/kg of kerosene & kg Nicotine/kg of water.
8 + 7



10. A tray tower is to be designed to absorb SO_2 from an air stream by using pure water at 293 K . The entering gas contains 20 mol% SO_2 and that leaving 2 mol% at a total pressure of 101.3 kPa. The air flow rate is 150 kg air/ hr.m² and the entering water flow rate is 6000 kg water/ hr.m². Assuming an overall tray efficiency of 25%, how many theoretical trays are needed ? Assume that the tower operates at 293 K. Equilibrium data is given by $Y^* = 20X$.
11. Experiments at 25° C were performed to determine the permeability of a cellulose acetate membrane. The laboratory test section has membrane (10g NaCl/L; density = 1004 kg solution/ m³). The water recovery is assumed low so that the concentration C_1 in the entering feed solution flowing past the membrane and the concentration of the exit feed solution are essentially equal. The product solution contains $C_2 = 0.39$ kg NaCl/ m³ (density = 997 kg solution/ m³) and its measured flow rate is 1.92×10^{-8} m³ solution/sec. A pressure differential of 5514 Pa is used. Calculate the permeability constant of the membrane and the solute rejection R.
-