



Name :

Roll No. :

Invigilator's Signature :

**CS/B.TECH (FT)/SEM-5/CHE-514/2010-11
2010-11**

UNIT OPERATION OF CHEMICAL ENGINEERING-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)**

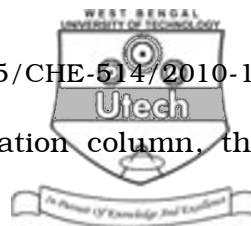
1. Choose the correct alternatives for the following :

10 ∞ 1 = 10

- i) Boiling point diagram is
 - a) not effected by pressure
 - b) affected by pressure
 - c) a plot of temperature *vs* liquid composition
 - d) a plot of temperature *vs* vapour composition.
- ii) Raoult's law is applicable to
 - a) ideals solutions
 - b) real solutions
 - c) the mixture of water and alcohol
 - d) non-ideal gases.



- iii) Henry's law states that the
- partial pressure of a component over a solution is proportional to its mole fraction in the liquid
 - partial pressure of a component over a solution is proportional to its mole fraction in the vapour
 - vapor pressure is equal to the product of the mole fraction and total pressure
 - partial pressure is equal to the product of the mole fraction and total pressure.
- iv) In azeotropic mixture, the equilibrium vapor composition is
- more than liquid composition
 - less than liquid composition
 - same as liquid composition
 - independent of pressure.
- v) Boudary Layer theory relates average mass transfer coefficient (K) with diffusivity (D) as
- $K \propto D^{0.5}$
 - $K \propto D^{2/3}$
 - $K \propto D$
 - $K \propto D^3$.
- vi) Relative volatility AB stands for
- $(X_A / Y_A) / (Y_B / X_B)$
 - $(Y_A / X_A) / (Y_B / X_B)$
 - P_A^{sat} / P_B^{sat}
 - both (b) and (c).



- vii) At total 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.
- viii) A vapor liquid mixture containing 75% liquid is used as feed for distillation. The value of q is
- $3/4$
 - $1/4$
 - $1/2$
 - 1.
- ix) Leaching is
- Gas-liquid mass transfer
 - Gas-solid mass transfer
 - Liquid-liquid mass transfer
 - Solid-liquid mass transfer.
- x) For the case of Cracking reaction
- $\text{CH}_4 \rightarrow \text{C} + 2\text{H}_2$, CH_4 (A) diffuses to the cracking surface and H_2 diffuses back. If the fluxes are N_A and N_B respectively then $N_A/N_A + N_B$ equals to
- 0
 - 1
 - 1
 - $1/2$.



GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following.

3 \times 5 = 15

2. Derive the expression for overall mass transfer coefficient when the system is liquid film controlling.
3. Explain briefly the operating principle of a Packed Tower.
4. Define diffusivity. CH_4 diffuses at steady state through a tube containing He. At point 1 the partial pressure of CH_4 is $p_A = 55$ kPa and at point 2, 0.03 m apart $p_A = 15$ kPa.

The total pressure is 101.32 kPa and temperature 298 K. At this temperature and pressure the value of diffusivity is $6.75 \times 10^{-5} \text{ m}^2/\text{s}$.

Calculate the flux of CH_4 at steady state for equimolar counter diffusion.

2 + 3

5. The temperature of air in a room is 40.2°C and the total pressure is 101.3 kPa. The air contains water vapour with a partial pressure p_A is 3.74 kPa. Calculate (i) the humidity, (ii) the saturation humidity and % humidity, (iii) the % relative humidity.
6. A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 25 wt % Na_2CO_3 is cooled at 293 K and crystals of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ are precipitated. At 293 K, the solubility is 21.5 kg anhydrous Na_2CO_3 /100 kg of total water. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling.

1 + 2 + 2

**GROUP – C****(Long Answer Type Questions)**Answer any *three* of the following.

3 × 15 = 45

7. a) What is Murphree plate efficiency of a distillation column ?
- b) Define NTU and H.T.U. of a distillation column.
- c) A liquid feed at its boiling point of 400 kg-mol/h containing 70 mol % of benzene (A), 30 mol % of toluene (B) and fed to a stripping tower at 101.3 kPa pressure. The bottom product flow is to be 60 kg-mol/h containing only 10 mol % of A and rest B. Calculate the kg-mol/h of overhead product, its composition and number of theoretical trays required. The equilibrium data of benzene toluene system is given below :

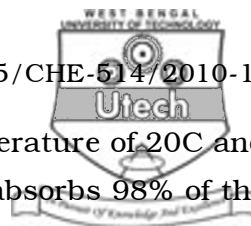
X :	1.000	0.700	0.581	0.411	0.258	0.130	0
Y :	1.000	0.900	0.777	0.632	0.456	0.261	0

2 + 3 + 10

8. a) What is the basic principle of extraction of solid ?
Extraction of solids is sometimes pH dependent. Explain.
- b) What is separation factor in an extraction process ?
Deduce an expression for kinetics of mass transfer during extraction process.



- c) Penicillin is extracted from a fermentation both using isoamylacetate as organic solvent in a continuous counter current cascade extraction unit. The flow rates of organic (l) and aqueous (h) phases are $L = 10$ l/m and $H = 100$ l/m respectively. The distribution coefficient of penicillin between organic and aqueous phases at pH = 3 is 50. If the penicillin concentration in the feed stream is 20 g/l, determine the number of stages required to reduce the penicillin concentration 0.1 g/l in the effluent of extraction unit. 4 + 5 + 6
9. a) A packed tower is to be designed to absorb SO_2 from air by scrubbing with water. The entering gas is 20% SO_2 by volume and leaving gas is to contain 0.5 % SO_2 by volume. The entering water SO_2 free. The water flow is to be twice the minimum. The pure air (on SO_2 free basis) flow rate is 975 kg/hr.m^2 at 303 K and 2 atm pressure. The equilibrium data is governed by $y = 21.8 x$, x & y are in mole fraction units. Compute the number of gas transfer units. 11
- b) Briefly discuss about the different types of plate type towers for absorption process. 4
10. a) Derive the relation between overall and individual mass transfer coefficient.
- b) A mixture of acetone vapour & air containing 5% by volume of acetone is to be free of its acetone content by scrubbing it with water in a packed bed absorber. The flow rate of the gas is $700 \text{ m}^3/\text{h}$ of acetone-free air measured at NTP and that of water is 1500 kg/h. The



absorber operates at an average temperature of 20°C and a pressure of 101 kPa. the scrubber absorbs 98% of the acetone. The equilibrium relationship for acetone-vapour water system is $Y^* = 1.68 X$, where Y-kmol of acetone/K mol of dry air & X-kmol of acetone/Kmol of dry water. Calculate the mean driving force for absorption & the mass transfer area if the overall mass transfer coefficient is 0.4 K mol of acetone/m² h. 7 + 8

11. Describe any *three* unit operations :

$3 \times 5 = 15$

- a) Ultrafiltration
- b) Electrodialysis
- c) Pervaporation
- d) Reverse osmosis
- e) Dialysis.
