

JK LAKSHMIPAT UNIVERSITY, JAIPUR
INSTITUTE OF ENGINEERING AND TECHNOLOGY
End Term Examination (Regular/ Backlog), April-May 2018
B. Tech/ M. Tech (as applicable) in Chemical Engineering, Semester Fourth

Roll No.....

COURSE CODE: CHE407

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Mass Transfer Operations-I

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

- Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10**
- i. 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 the above
 - ii. At the boiling point of the liquid at the prevailing pressure the saturated absolute humidity becomes
(a) one (b) zero (c) infinity (d) None of the above
 - iii. The psychrometric ratio is defined as
(a) $\frac{h_G}{k_y}$ (b) $\frac{k_y}{h_G}$ (c) $\frac{h_G}{k_y C_s}$ (d) $\frac{S_c}{P_r}$
 - iv. In a cooling tower makeup fresh water must be added to replace losses from
(a) entrainment (b) evaporation losses (c) blowdown (d) all of the above
 - v. Separation of a binary mixture of gases by absorption in the liquid solvent depends upon their differences in
(a) Density (b) solubility (c) viscosity (d) kinematic viscosity
 - vi. According to the penetration theory the mass-transfer coefficient is directly proportional to
(a) D_{AB} (b) D_{AB}^2 (c) $D_{AB}^{1.5}$ (d) $D_{AB}^{0.5}$
 - vii. For a single component absorber the operating line is straight only when plotted in terms of
(a) The mole fraction units (b) the partial pressure unit
(c) the mole ratio units (d) all of the above
 - viii. The Chilton Coburn analogy for mass transfer state that
(a) $StSc^{0.33}=f/8$ (b) $StSc^{0.66}=f/2$ (c) $StSc^{1.5}=f/2$ (d) $StSc^{0.66}=f/8$
 - ix. The solubility of a particular gas in ideal solution in any solvent is
(a) Always the same (b) Always the different (c) Always zero (d) none of the above
 - x. The Lewis number of a mixture is one when mass diffusivity is equal to
(a) movement diffusivity (b) thermal diffusivity
(c) thermal conductivity (d) 1/thermal diffusivity
- Q.2 Short answer type questions (4 questions @ 2.5 marks) 10**

A.	How to explain the Fick's first law of diffusion in mass transfer operation.	
B.	How does the binary gas-phase diffusivity depend upon the total pressure and temperature?	
C.	Explain the Roult's law and Henry's Law, its application in mass transfer operation.	
D.	What are the importance and applications of mass transfer and heat transfer analogies?	
Q.3A	Drive the flux equation for equimolar counter diffusion for binary system in mass transfer operation.	05
Q.3B	CO ₂ is diffusing through non-diffusing air under steady state conditions at a total pressure of 1 atmosphere and temperature of 300 K. the partial pressure of CO ₂ is 20kPa and one point and 5kPa at other point. The distance between the points is 5cm. calculate the flux of CO ₂ . The diffusivity of CO ₂ -air at the above condition is 0.00002 m ² /s.	05
Q.4A	Drive the flux equation for diffusion in uniformly tapered equilateral triangle geometry.	05
Q.4B	Calculate the mass flux of benzene through a layer of air 10 mm thickness at 25°C and 200 kN/m ² total pressure, partial pressure of benzene is 6000 N/m ² , at the left side of the layer and 1 kN/m ² at the right side. The mass diffusivity of benzene at the above temperature and pressure is 0.0000044 m ² /sec.	05
Q.5A	What are the diffusivity and derive the correlation for diffusivity of gases, its significances.	05
Q.5B	Determine the diffusivity of CO ₂ (1), O ₂ (2) and N ₂ (3) in a gas mixture having the composition, CO ₂ :28.5%, O ₂ :15%, N ₂ :56.5%. the gas mixture is at 273 K and 1.2x10 ⁵ Pa. the binary diffusivity values are given at 273 K as: D ₁₂ P=1.874 m ² Pa/sec, D ₁₃ P=1.945 m ² Pa/sec, D ₂₃ P=1.834 m ² Pa/sec.	05
Q.6A	Define and drive the correlation to calculate the mass flux in terms of the individual mass transfer coefficient.	05
Q.6B1	Calculate the convective mass transfer coefficient in a wetted wall tower for the transfer of benzene into CO ₂ at 0°C. The gas velocity through the column is 1.25 m/s. the diameter of the column is 0.16m. Assume that benzene concentration in CO ₂ is very low. The density and viscosity of CO ₂ are 1.966 kg/m ³ and 1.35x10 ⁻⁵ kg/m. sec, diffusivity of benzene to CO ₂ is 0.00000528 m ² /sec.	05
OR		
Q.6B2	Define the following terms moisture content, bound moisture, unbound moisture, equilibrium moisture and free moisture.	05
Q.7A	Drive the equation for design of packed tower based on the total mass transfer coefficient.	05
Q.7B1	A packed tower is designed to recover 98% CO ₂ from gas mixture containing 10% CO ₂ and 90% air using water. The equilibrium relation is y=14x. The water to gas rate is kept 30% more than the minimum value. Calculate the height of tower if (HTU) _G is 1 m.	05
OR		
Q.7B2	What are the vacuum rotary dryer, explain its working principle with suitable diagram. .	05
Q.8A	What are the criteria for the selection of adsorbents for the adsorption processes	5

in mass transfer operation?

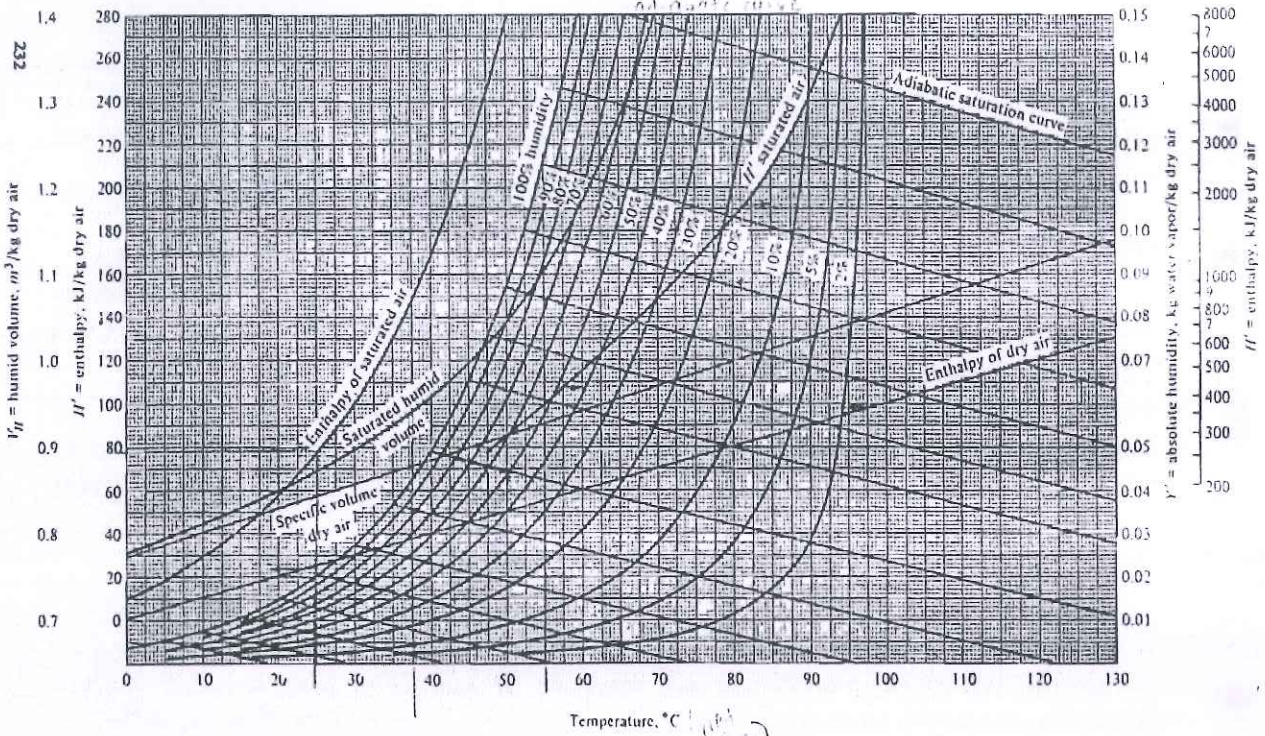
- Q.8B1 It is necessary to dry a batch of 160 kg of a wet material from 30% to 5% moisture content, under constant rate and falling rate period. The falling rate is assumed to be linear. Calculate the total drying time considering an available drying surface of $1 \text{ m}^2/40\text{kg}$ of dry solid. A constant dry flux of $3 \times 10^{-4} \text{ kg/m}^2$ is given at critical moisture content $0.2 \text{ kg moisture/kg solid}$ and equilibrium moisture contents 0.05 . 5

OR

- Q.8B2 What is the activated carbon, write the preparation methods and its properties. 5
- Q.9A A mixture of air and water-vapor has a dry bulb temperature of 60°C and an absolute humidity of $0.03 \text{ kg-water vapor/kg-dry air}$. The system pressure is at 1 atmosphere absolute. Find out the followings: 10
1. Saturation absolute humidity, 2. Relative humidity, 3. Dew point temperature, 4. humid volume, 5. Humid heat, 6. Enthalpy, 7. Heat required to heat 1.2 m^3 of this mixture to 120°C , 8. Adiabatic saturation temperature, 9. Wet bulb temperature.
- Q.9B1 Drive the correlation for time required for drying operation with diagram. 10
- Q.9B2 A wetted-wall column, width 20cm diameter, is used for absorbing a solute 'ammonia' from an Ammonia air mixture at 100 kPa . The solvent vapour pressure and the solubility of air in the solvent are negligible. The equilibrium data are plotted. At a certain column location, the steady state liquid and gas phase mole fraction of 'ammonia' are 0.02 and 0.07 , respectively, and the liquid and gas side mass transfer coefficients are estimated to be 70 and $50 \text{ kmol/m}^2\text{h}$ respectively. Calculate the following at this location. The equilibrium mole fraction: y_{Ai} and x_{Ai} , the mass transfer coefficients: k_G , K_y and K_x . and the molar absorption rate of 'ammonia' per unit column height. 10

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At 50°C and 50% relative humidity if head took cool air
at 20°C and 100% humidity



*****Good Luck*****