Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) - EXAMINATION – SUMMER 2018

Subject Code: 2163609 Date: 28/04/2018

Subject Name: Basics of Mass Transfer

Time: 10:30 AM to 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** State Fick's law of diffusion and prove that $D_{AB} = D_{BA}$. 03

(b) State and discuss the types of diffusion with suitable example. 04

(c) Derive the steady state equimolar counter diffusion equation for liquids. 07

Q.2 **(a)** At $1*10^5$ N/m^2 total pressure, if the mixture of methane and hydrogen is in the volume ratio of 2:1, what will be partial pressure of methane gas in the mixture? 03

(b) Differentiate N and J flux with an example. 04

(c) Explain "Two-resistance theory" for overall mass transfer coefficient in case of interphase mass transfer. 07

OR

(c) Classify the mass transfer operations based on direct contact of two miscible phases. 07

Q.3 **(a)** Discuss mass transfer coefficients for gases. 03

(b) Explain Two component system equilibrium solubility of gases in liquid with neat diagram. 04

(c) Explain Penetration theory with the example of bubble. 07

OR

Q.3 **(a)** Explain surface renewal theory. 03

(b) Explain minimum gas-liquid ratio for absorbers with neat diagram. 04

(c) Calculate the rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 1 mm thick at 17^0C when the concentrations on opposite sides of the film are, respectively, 9 and 3 wt % acid. The diffusivity of acetic acid in the solution is $0.95 * 10^{-9}$ m^2/s. 07

The density of 9 % solution is 1012 kg/m^3,

The density of 3 % solution is 1003.2 kg/m^3

Q.4 **(a)** Define Free moisture, bound moisture and unbound moisture. 03

(b) Explain different types of distillation. 04

(c) The gas leaving an alcohol fermenter consists of 10% CO_2 and 90% air. 80 % of the CO_2 in the gas is to be recovered by absorbing in a water solution of triethanolamine containing 0.01 mole CO_2 per mole of CO_2 free amine solution. Absorption is carried out at 298 K. Amine is supplied 40 % in excess of the minimum. The equilibrium data for 298 K is: (X=mole CO_2/mole amine; Y= mole CO_2/mole air) 07

X	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11
Y	0.003	0.008	0.015	0.023	0.032	0.043	0.055	0.068	0.083	0.099	0.12

Determine for treating 100 kmol/h feed gas:

1) The minimum solvent required, kmol/h
2) The solvent required, kmol/h
3) Mole percent of CO_2 in the exit liquid

OR

Q.4 **(a)** State selection criteria for choice of solvent for absorption. 03

(b) Derive the equation of wet bulb temperature. 04

(c) A porous solid is dried in a batch dryer under constant drying conditions. 9 hours are required to reduce the moisture content from 45 to 10%. The critical moisture content was found to be 25% and the equilibrium moisture 3%. All moisture contents are on the dry basis. Assuming that the rate of drying during falling rate period is proportional to the free moisture content, how long should it take to dry a sample of same solid from 35 to 5% under the same drying conditions? 07

Q.5 **(a)** Define with expression the humid volume and humid heat. 03

(b) Explain with neat sketch the rate of drying curve in detail. 04

(c) An air-water vapor sample has a dry bulb temperature 54 ^{0}C and an absolute humidity 0.01 kg water/ kg dry air at 1 std atm pressure. Calculate percentage humidity, molal absolute humidity, partial pressure of water vapor, dew point and humid volume. 07

OR

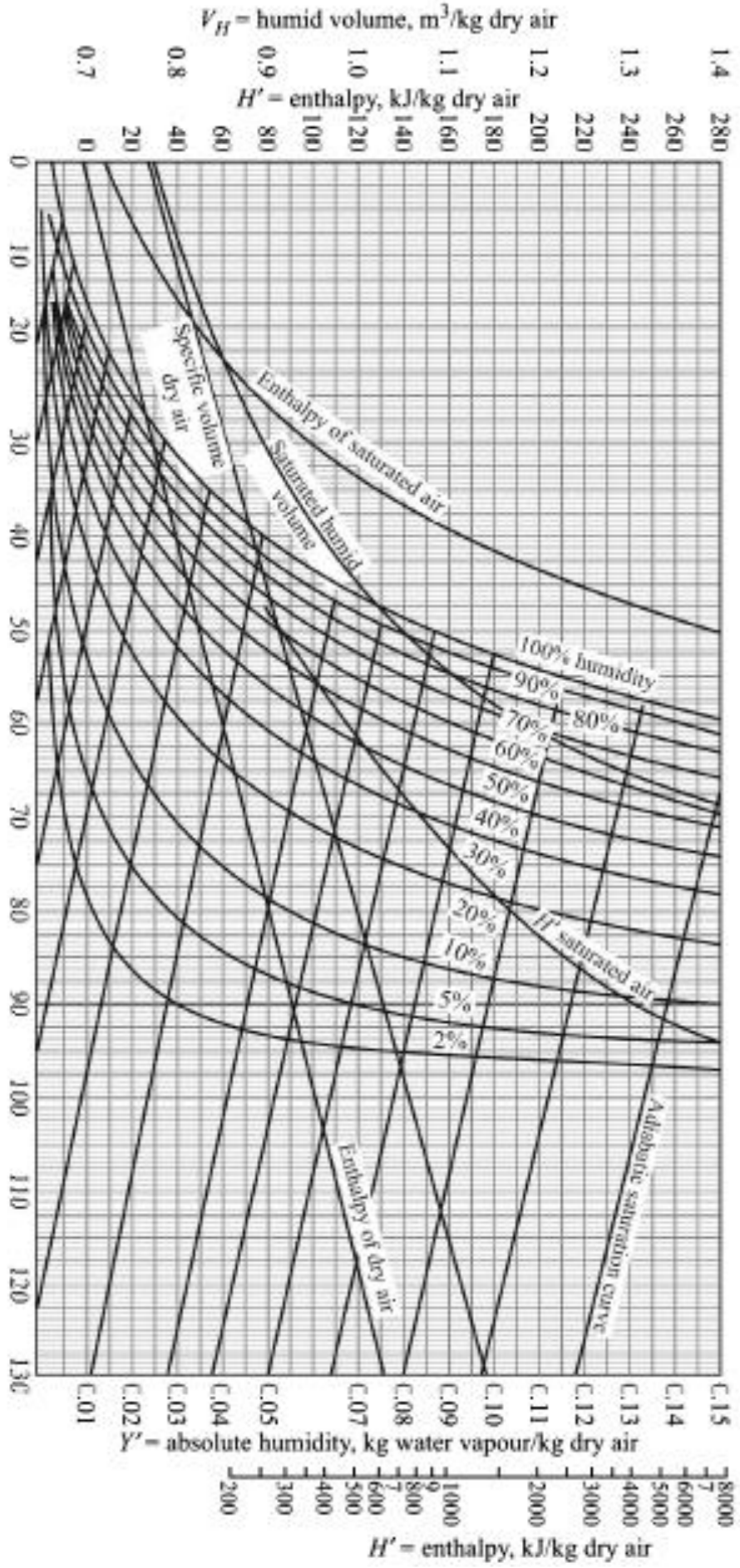
Q.5 **(a)** Explain 1) Relative volatility (2) Raoult's law (3) Dry Bulb Temperature 03

(b) Derive Rayleigh equation for a binary mixture. 04

(c) A batch of solid for which the material is dried from 25 to 10% moisture has the initial weight of solid to be 160 kg. The drying surface is 1 m^2/40 kg dry weight. Determine the time of drying for constant rate period and falling rate period using graph
ical method. The data are as follows: 07

X	0.35	0.3	0.25	0.2	0.16	0.14	0.12	0.1	0.09
N	0.3	0.3	0.3	0.3	0.239	0.208	0.18	0.15	0.097

Where X= kg moisture / kg dry solid
N= rate of drying x 10^3 , kg evaporated /m^2- sec.


V_H = humid volume, m³/kg dry air
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
H' = enthalpy, kJ/kg dry air
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Specific volume dry air
Saturated humid volume
Enthalpy of saturated air
100% humidity
90%
80%
70%
60%
50%
40%
30%
20%
10%
5%
2%
H' saturated air
Adiabatic saturation curve
Enthalpy of dry air
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0.01
0.02
0.03
0.04
0.05
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.14
0.15
Y' = absolute humidity, kg water vapour/kg dry air
200
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000
H' = enthalpy, kJ/kg dry air