Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

IV SEMESTER B.TECH (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: MASS TRANSFER -I (CHE 2203)

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 100

Instructions to Candidates:

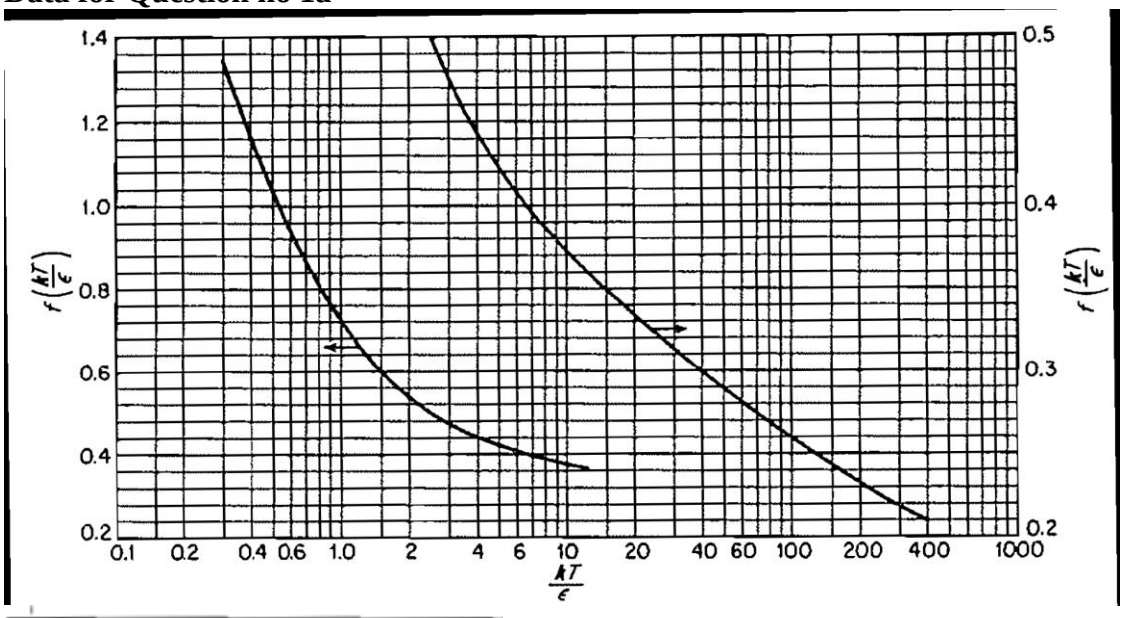
- Answer any **FIVE FULL** questions. Missing data may be suitably

1a	Estimate the diffusivity of Acetone ($(CH_3)_2CO$; MW=58, Boiling point is 56 ^{0}C) through air (MW= 29) at STP condition. Data is provided below.	**15**
1b	Calculate the rate of diffusion of acetic acid across a film of equi-molal counter current diffusing water solution (2 mm thick at 17^{0}C) when the mole fraction of acetic acid at two locations in solution are 0.0288 and 0.0092. The diffusivity of acetic acid in water at this conditions is 9.5x10^{-10} m^2/s. The $\frac{\rho}{M_{av}} = 53.6\ kmol/m^3$.	**5**
2	It is desired to dry 20 kg of soap from 18% moisture (MW=18) by weight to a desirable value in three stages by contact with hot air (MW=29). The wet soap is placed in container of total volume of 9 m^3 out of which 2 m^3 is occupied by wet soap and rest is air at 350 K, 1 atm and water vapor partial pressure is 2 kPa. The system is allowed to reach equilibrium and then air is replaced with fresh air with original moisture content and same conditions. What is the final concentration of soap after three stages? Assume the change in soap volume due to loss of moisture is negligible in all stages. The equilibrium data of X and Y is given below.	**20**

X (mole ratio)	0.025	0.05	0.085	0.145	0.182	0.235
Y (mole ratio)	0.008	0.024	0.04	0.056	0.065	0.073

3a	Estimate average mass transfer coefficient of pure oxygen at 10 atm and 25 ^{0}C into water flowing as film down a vertical wall of 1m high and 6 cm width at a Reynolds number of 60 without ripples. The diffusivity of oxygen in water 2.5x10^{-9} m^2/s	**8**
3b	i) Define gas, liquid holdup ii) Draw a graph representing the liquid rate vs gas rate in gas liquid operations and explain the various mechanical difficulties arises in equipment due to gas and liquid flow rates	**3** **9**
4a	Calculate the minimum steam rate for given stripper and compute the number of stages with 1.5 times of minimum steam rate. (counter current) The oil with a circulation rate of 3x10^{-3} kmol/s, is entering to stripper with 1% by volume against fresh steam to reduce the oil concentration to 0.5% by volume. The relation of liquid and gas mole ratios as follows $\frac{Y}{Y+1} = 3.16\ \frac{X}{X+1}$	**15**
4b	Briefly explain the properties of solvent required for absorption i.e Gas solubility, volatility	**5**
5a	Hydrogen gas at 2 atm and 25 ^{0}C flows through a pipe made of unvulcanised neoprene rubber.(I.D= 25 mm and O.D= 50 mm). The solubility of H_2 is 0.053 cm^3(STP)/cm^3.atm and diffusivity is 1.8x10^{-10} m^2/s. Estimate the rate of loss of	**5**

	hydrogen diffusion per meter of pipe length.	
5b	Briefly explain the molecular diffusion through crystalline solids	**4**
5c	List at least six differences between physisorption and chemisorption What type of isotherms are used to represent the adsorption phenomena and explain briefly?	**6** **5**
6	An aqueous solution containing a valuable solute is coloured by small amounts of impurity. This color is removed by carbon as adsorbent. A series of laboratory tests was made by stirring various amounts of the adsorbent into batches of original solution until equilibrium was established, the data is represented by Freundlich isotherm $Y^* = 8.91x10^{-5}\ X^{1.66}$. The colour intensity was measured on an arbitrary scale, proportional to the concentration of the colored substance. It is desired to reduce the colour to 5% of its original value, 9.6. Determine the minimum quantity of used carbon (X=35) required per 1000 kg of solution for a two stage cross current operation.(Freundlich isotherm method and Graphical method)	**20**
	Data for Question no 1a	



Gas	ϵ/k, K	r, nm
Air	78.6	0.3711

Atomic volume, $m^3/1000$ atoms $\times 10^3$		Molecular volume, $m^3/kmol \times 10^3$		Atomic volume, $m^3/1000$ atoms $\times 10^3$		Molecular volume, $m^3/kmol \times 10^3$	
Carbon	14.8	H_2	14.3	Oxygen	7.4	NH_3	25.8
Hydrogen	3.7	O_2	25.6	In methyl esters	9.1	H_2O	18.9
Chlorine	24.6	N_2	31.2	In higher esters	11.0	H_2S	32.9
Bromine	27.0	Air	29.9	In acids	12.0	COS	51.5
Iodine	37.0	CO	30.7	In methyl ethers	9.9	Cl_2	48.4
Sulfur	25.6	CO_2	34.0	In higher ethers	11.0	Br_2	53.2
Nitrogen	15.6	SO_2	44.8	Benzene ring: subtract	15	I_2	71.5
In primary amines	10.5	NO	23.6	Naphthalene ring: subtract	30		
In secondary amines	12.0	N_2O	36.4				