GIET MAIN CAMPUS AUTONOMOUS GUNUPUR – 765022

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4th Semester Regular Examination-April-May 2019

BCHPC 4020 – MASS TRANSFER-I

(Regulations 2017) Chemical Branch

Time : 3 Hours Maximum : 100 Marks

Answer ALL Questions

The figures in the right hand margin indicate marks.

PART – A: (Multiple Choice Questions) 10 x 2=20 Mark

Q.1. Answer *All* Questions.

a The molar average velocity of the components in a binary mixture in which they are in equimolar counter diffusion is [CO1] [PO1]
(a) equal to the mass average velocity (b) zero (c) always negative (d) always positive

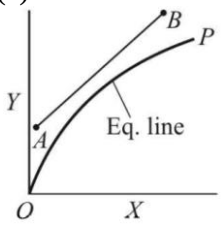
b Which of the following is a probable value of D_{AB} for CO_2-N_2 binary at 50 °C, 2 atm? [CO1] [PO1]
(a) 20 cm^2/s (b) 2.25 ft^2/h (c) 10-5 m^2/s (d) 15 m^2/s

c The breathing process within the lungs involves [CO1] [PO1]
(a) diffusion of A through non-diffusing B (b) equimolar counter diffusion
(c) multicomponent non-equimolar counter diffusion (d) Knudsen diffusion

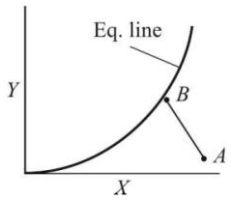
d Under which of the following conditions the gas-phase driving force will be constant along the column? [CO2] [PO1]
(a) L/G = 1 (b) L > G and m=1 (c) L/G = m (d) None of the above

e Equilibrium and operating lines (OP and AB) for four gas-liquid contacting operations are shown in the following figures. Which of the figures represents an equilibrium co-current unit (i.e. having 100% stage efficiency)? [CO2] [PO1]

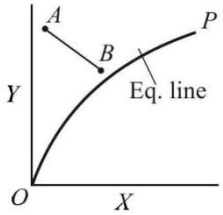
(a)



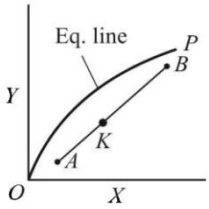
(b)



(c)



(d)



f Which of the following quantities is appreciably dependent on the solubility of a gas in the solvent? [CO2] [PO1]
(a) HTU (b) NTU (c) ā (specific interfacial area) (d) None of the above

g The relative volatility of A in mixture with B is α_{AB}= 2.0. What is the value of α_{BA}? [CO3] [PO2]
(a) 2.0 (b) 0.5 (c) 1.0 (d) None of the above

h In binary distillation, the separation of the components is easier if the relative volatility (α) is [CO3] [PO2]
(a) α>>1 (b) α<<1 (c) α=1 (d) None of the above

i In a cooling tower terminology, the "range" means [CO4] [PO1]
(a) the reduction in temperature of the warm water (b) the difference between the maximum and minimum air flow rates (c) the change in the air temperatures (d) none of these

j In a mechanical draft cooling tower, the L/G ration generally lies between [CO4] [PO1]
(a) 1-4 (b) 0.75-1.5 (c) 0.25-0.75 (d) None of these

PART – B: (Short Answer Questions) 2x10=20 Marks

Q.2. Answer *ALL* questions

a What is equimolar counter-diffusion? [CO1] [PO1]

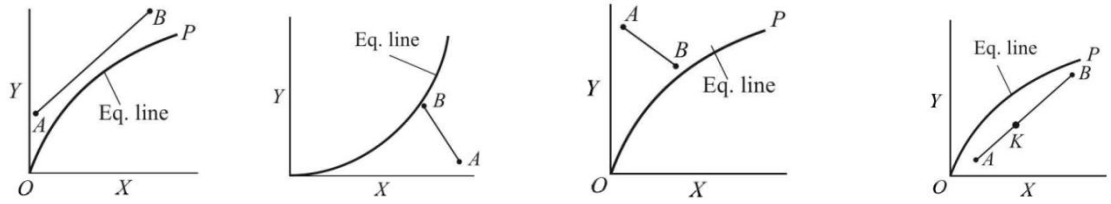
b Consider diffusion of A in non-diffusing B through a constant area from $z=z_1$, $p_A=p_{A1}$ to $z=z_2$, $p_A=p_{A2}$ (p_{A1}.p_{A2}). At which point in the diffusion path is the magnitude of the partial pressure gradient maximum? [CO1] [PO2]

c Consider two cases of diffusion of A through a gaseous mixture of A and B: [CO1] [PO1]
(i) B is non diffusing, (ii) B undergoes equimolar counter diffusion.

All the parameters (P, T, DAB, L, etc) as well as the terminal partial pressures of A are the same in both the cases.
In which case, the flux of A is larger? Give a qualitative explanation.

d Equilibrium and operating lines (OP and AB) for four gas-liquid contacting operations are shown in the following figures. Identify which figures are the cases of co-current and counter-current absorption/stripping. [CO2] [PO1]

(i) (ii) (iii) (iv)



e What is the physical significance of NTU? [CO2] [PO1]

f What is the physical significance of HTU? [CO2] [PO1]

g The vapor pressures benzene and toluene are 3 and 4/3 atmospheres respectively. A liquid feed of 0.4 moles of Benzene and 0.6 moles of Toluene is vaporized. Assuming that the products are in equilibrium, calculate the vapor phase mole fraction of benzene. [CO3] [PO2]

h In a binary distillation column, if the feed contains 40 mol% vapor, then find the q-line slope. [CO3] [PO2]

i What is wet bulb depression? [CO4] [PO1]

j What are the common packings and materials for cooling tower? [CO4] [PO1]

PART – C: (Long Answer Questions) 15x4=60 Marks

Q.3 Answer *ALL* questions

a. The diffusivity of carbon tetrachloride (CCl_4) through Oxygen (O_2) was determined in a steady state Arnold evaporating cell. The cell, having a cross sectional area of 0.82 cm^2, was operated at 273 K and 755 mmHg pressure. The average length of the diffusion path was 17.1 cm. If 0.0208 cc of CCl_4 was evaporated in 10 hours of steady state operation, what should be the value of the diffusivity of CCl_4 through oxygen? Take R value as 8314 J/ Kg K — 10 — [CO1] [PO1]

b. In an Oxygen-nitrogen gas mixture at 1 atm and 25 °C, the concentrations of oxygen at two planes 0.2 cm apart are 10% and 20% (by volume) respectively. Calculate the flux of oxygen when nitrogen is non diffusing. Diffusivity of oxygen in nitrogen is 0.215 cm^2/s. — 5 — [CO1] [PO2]

OR

c. Write short notes on — 10 — [CO1] [PO1]
i. Film theory (including assumptions)
ii. Penetration theory (including assumptions)
iii. Surface renewal theory

d. Ammonia diffuses through nitrogen gas under equimolar counter diffusion at a total pressure of 1.013×10^5 Pa and at a temperature of 298 K. The diffusion path is 0.15 m. The partial pressure of ammonia at one point is 1.5×10^4 Pa and at the other point is 5×10^3 Pa. Diffusivity under the given condition is 2.3×10^{-5} m^2/s. Calculate the flux of ammonia ($kmol/m^2$ s). — 5 — [CO1] [PO2]

Q.4

a. The CO_2 issuing out of a fermenter contains 0.01 mole fraction of ethanol, which has to be reduced to 0.0001 mole fraction by scrubbing with water in a counter current packed tower. The gas flow rate is 227.3 kmol/hr and may be assumed constant throughout the tower. The equilibrium mole fraction of ethanol in the gas phase y* is related to that in the liquid x as y*=1.07x. Determine the minimum liquid rate needed and the number of overall gas-side transfer units needed at 1.5 times the minimum liquid rate. The entering liquid may be assumed to be free of ethanol. — 8 — [CO2] [PO2]

b. Discuss the important criteria for the selection of solvent and stripping medium for absorption. — 7 — [CO2] [PO1]

OR

c.	An air-NH_3 mixture containing 5% NH_3 by volume is absorbed in water using a packed tower at 20 °C and 1 atm pressure to recover 98% NH3. Gas flow rate is 1200 kg/h m^2. Calculate minimum mass flow rate of liquid. The equilibrium relation is y=1.154x where, x, y are expressed in mole fraction units. (A4 Graph Paper required to solve the question)	8	[CO2] [PO2]
d.	Determine the relation between the gas-phase mass transfer coefficients k_G and k_Y.	7	[CO2] [PO1]

Q5.

a.	A fractionating column separates a liquid mixture entering at 5000 kmol/h containing 50 mol% A and 50 mol% B into an overhead product of 95 mol% A and a bottom product of 96 mol% B. A reflux ratio of twice the minimum will be used and the feed enters at its boiling point. Determine the number of theoretical stages required and the location of feed point. Use McCabe-Thiele method.	8	[CO3] [PO2]

Equilibrium data:

x	0.03	0.06	0.11	0.14	0.26	0.39	0.53
y	0.08	0.16	0.27	0.33	0.50	0.63	0.71
x	0.66	0.76	0.86	1.0			
y	0.83	0.88	0.93	1.0			

x.y mole fraction of A in liquid and vapor phase respectively. (A4 Graph paper is required)

b.	State Raoult's law.	7	[CO3] [PO2]

OR

c.	Discuss the deviation from ideality and formation of azeotropes.	8	[CO3] [PO2]
d.	Derive the Fenske's equation.	7	[CO3] [PO1]

Q.6

a.	Air at a temperature of 30 °C and a pressure of 100 kPa has a relative humidity of 80%. (i) Calculate the molal humidity of air (ii) Calculate the molal humidity of this air if its temperature is reduced to 15 °C and its pressure increased to 200 kPa, condensing out some of the water. (iii) Calculate the weight of water condensed from 100 m^3 of the original wet air in cooling to 15 °C and compressing to 200 kPa. (iv) Calculate the final volume of the wet air of part (iii).	8	[CO4] [PO2]
b.	Discuss the construction and working of a counter flow induced draft cooling tower with a neat diagram.	7	[CO4] [PO1]

OR

c.	An air-water vapor sample has a dry bulb temperature of 55 °C and an absolute humidity 0.03 kg water/kg dry air at 1 standard atm pressure. Using humidity chart. If vapor pressure of water at 55 °C is 118 mm Hg, calculate the relative humidity, the humid volume in m^3/kg dry air, enthalpy in J/kg dry air and the heat required if 100 m^3 of this air is heated to 110 °C.	8	[CO4] [PO2]
d.	Discuss the hygrometer method of humidity measurement.	7	[CO4] [PO1]

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