Ex/ChE/PC/B/T/311/2023(S)

B.E. CHEMICAL ENGINEERING 3RD YEAR 1st SEMESTER SUPPLEMENTARY EXAMINATION 2023

SEPARATION PROCESS I

Time : Three hours | Full Marks : 100

(50 Marks foe each Part)

Use separate Answer Script for each Part

PART I

Answer any two questions

The symbols have their usual meaning

1 (a) Derive the expression of steady state equimolar counter diffusion of A through B in stagnant gas?

(b) Oxygen is diffusing through a stagnant gas mixture containing nitrogen. The total pressure is 200 kN/m^2 and the temperature is 40 °C. Calculate the mass transfer flux of diffusion of oxygen in $Kmol/m^2.s$ through the film of gas 0.05 mm thick when the concentration change across the film changes from 8.0 % by volume to 2.0% ammonia by volume. The diffusivity of oxygen in nitrogen may be assumed to be 0.80×10^{-5} m^2/s.

© Derive the correlation $F = k'_G p_t = k'_c c$

2. Air containing sulfur dioxide is contacted with water countercurrently in a packed tower. At a certain point in the tower, the concentration of SO_2 in air is 8.0% by volume, whereas SO_2 in water is 0.5 weight %. The temperature and pressure in the tower was 25 °C and 1.25 bar whereas the density of the SO_2- liquid water was 990 kg/m^3. The overall mass transfer coefficient based on gas phase concentration was $K_G = 10.0 \times 10^{-10}$ $kmol/m^2.s$. Of the total diffusional resistance 50% lies in the gas phase.

(a) Determine the interfacial composition in both the phases in terms of mole fraction.
(b) Does the process occurring at this point correspond to absorption or stripping?
(c) Calculate the overall coefficient based on liquid mole fraction, K_x .
(d) The local mass transfer flux, $mole/m^2.s$ at this point

The equilibrium data at 25 °C for sulphur dioxide-water system is given below

Kg SO_2/kg water	0.2	0.3	0.5	0.7
Partial pressure SO_2, mm Hg	29	46	83	119

3 (a) A gas containing 'X' vapor (5 mol% X) is scrubbed from the gas by contacting it fresh wash oil countercurrently in a staged scrubber. 80% of X present in the gas mixture is to be removed. Pressure in absorber is 1000 mm Hg. Determine the number of stages if the wash oil used is 1.30 times the minimum. The Henry's-law constant $m = \frac{y^*}{x}$ for X-wash oil system is 0.10.

(b) Describe venture scrubber and packed bed equipment for continuous absorption (20 + 5)

[Turn over

Ref. No.: Ex/Che/PC/B/T/311/2023(S)

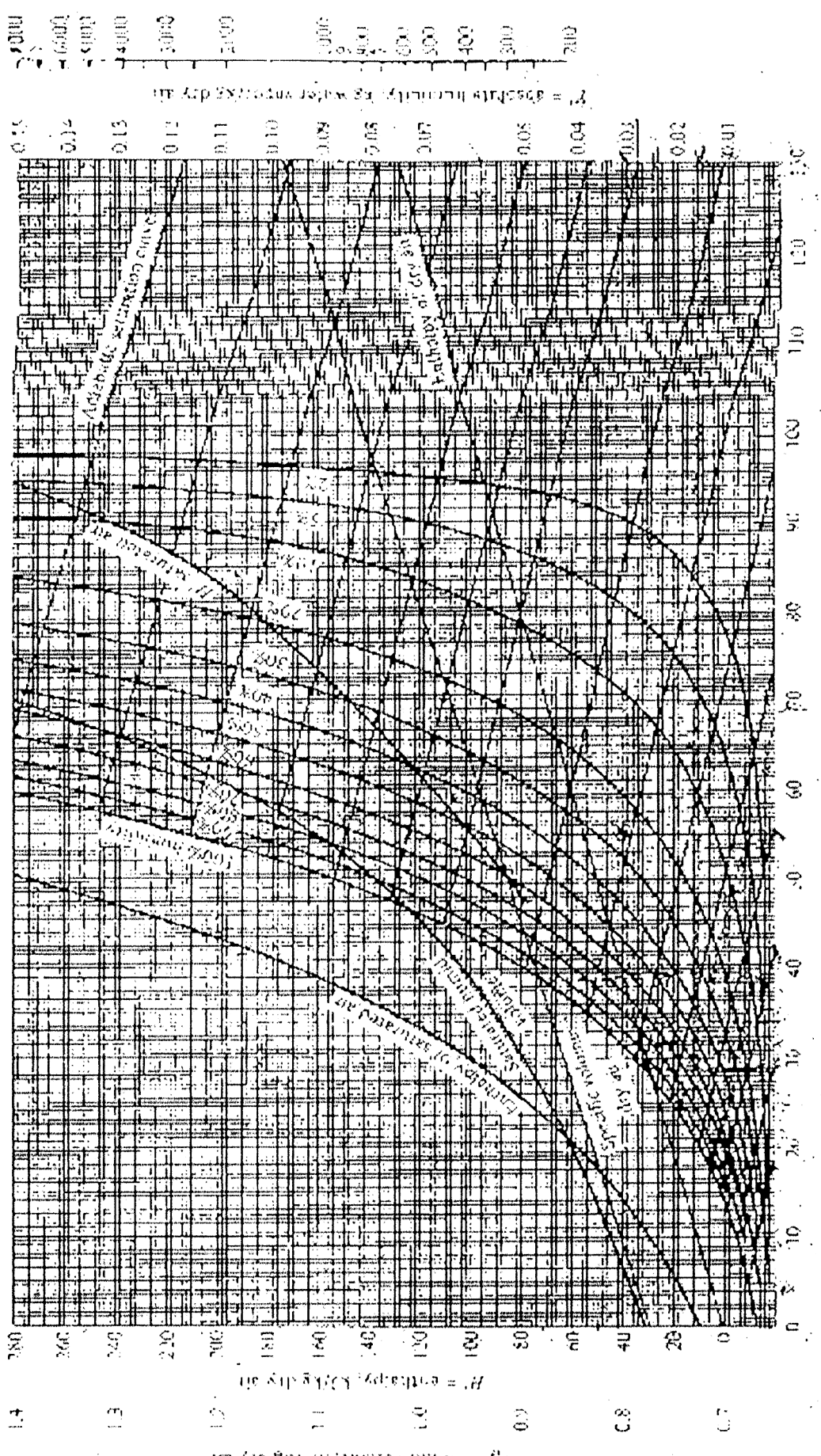
BACHELOR OF CHEMICAL ENGINEERING EXAMINATION, 2023
(3rd Year, 1st Semester)
SEPARATION PROCESSES I

Assume any missing data
Answer any **two (2)** questions

PART: II (50 Marks)

<table>
<tr><th>Question No</th><th>CO No.</th><th>Question</th><th>Marks</th></tr>
<tr><td>1.A</td><td>CO-3</td><td>A gas mixture containing 0.20 mole fraction of CO_2 is to be scrubbed to reduce its CO_2 mole fraction to 0.002, using 15.3 wt % aqueous mono ethanolamine (MEA) solution at 25°C and 1000 mm Hg pressure. The components other than CO_2 in the gas mixture may be treated as inert. The MEA solution enters the tower counter-current mode and contains 0.46 mol of CO_2 per mol of MEA in the solution. If the MEA used is 1.2 times the minimum, find the minimum MEA flow rate to get desired separation and number of theoretical stages required for the separation. Assume the solution to be concentrated.
<table>
<tr><td>P_{CO_2} (mm Hg)</td><td>2</td><td>7.5</td><td>10</td><td>20</td><td>30</td><td>40</td><td>50</td></tr>
<tr><td>CO_2 (mol per mol of MEA solution)</td><td>0.475</td><td>0.50</td><td>0.51</td><td>0.53</td><td>0.55</td><td>0.565</td><td>0.575</td></tr>
</table></td><td>20</td></tr>
<tr><td>1.B</td><td>CO-2</td><td>Hydrogen diffuses through a non-porous polyvinyl trimethylsilane membrane at 25°C. The pressures on the sides of the membrane are 3.5 MPa and 200 kPa. If the hydrogen flux is to be 0.64 kmol/m^2-h, how thick should the membrane be?
Diffusivity and solubility data: 160 x 10^{-11} m^2/s and 0.54 x 10^{-4} mol/m^3-Pa</td><td>5</td></tr>
<tr><td>2.A</td><td>CO-4</td><td>i) Absorption operations are generally gas film controlled. What does it mean? When does it occur?</td><td>4</td></tr>
<tr><td></td><td>CO-1</td><td>ii) Show that wet-bulb lines and adiabatic saturation lines are collinear.</td><td>3</td></tr>
<tr><td></td><td>CO-1</td><td>iii) Calculate the time required to reduce the diameter of a naphthalene ball to its 40% of its original size in air.</td><td>8</td></tr>
<tr><td>2.B</td><td>CO-3</td><td></td><td>10</td></tr>
</table>

		The total drying time needed for a batch of solid is 13.14 hrs. The weight of the wet solid is 160 kg and initial and final moisture content of the solid are 25 and 6% respectively. The drying surface is 1 m^2/40 kg of dry weight. The critical moisture content of the solid is 0.2 kg moisture/kg dry solid. The rate of drying at the constant rate period is given as 0.003 kg water/m^2-s. Find the slope of the falling rate region assuming b zero in N = mX+b.	
3.A	CO-2	The overhead condenser in distillation tower requires 20 kg/s of cooling water removing 270 watts of heat. The water will leave the condenser at 45°C. It is cooled to an induced draft cooling tower. The entering air is at 24°C wet-bulb temperature and 30°C dry bulb temperature. The water need to be cooled to within 7°C of the inlet air wet bulb temperature. An air/water (v) ratio of 1.25 times the minimum is used. The make-up water will come from a well at 10°C, hardness 500 ppm dissolved solids. The circulating water should not exceed 2000 ppm hardness. In the tower packing, Kyap = 0.9 kg/m^3-s. This is for gas rate of 2 kg/m^2s and a liquid rate at 2.7 kg/m^2s. Compute the dimensions of the packed section and make-up water requirement.	**22**
3.B	CO-1	Describe the Gas-liquid contacting pattern in wetted wall tower.	**3**



Psychrometric chart for air-water vapor, 1 std atm abs, in SI units.