Q2) Ammonia is being cracked on a solid catalyst according to the reaction:

PPl = 33.4

$D_{AM} = 1.09 \times 10^{-4}$

$$2NH_3 \rightarrow N_2 + 3H_2$$

At one place in the apparatus where the pressure is 1 atm and the temperature is 200 ^{0}C the analysis of the bulk gas is 33.33% NH_3 (A), 16.67% N_2 (B), and 50% H_2 (C) by volume. The circumstances are such that NH_3 diffuses from the bulk gas stream to the catalyst and the products of the reaction diffuse back as if by molecular diffusion through a gas film in laminar flow of 1 mm thickness. The diffusion is controlled (chemical reaction very rapid) with the concentration of NH_3 at the catalyst surface equal to zero. Also at 1 atm and 200 ^{0}C, $D_{AB} = 5.39 * 10^{-5}$ m^2/s, $D_{AC} = 1.66 * 10^{-4}$ m^2/s. Estimate the local rate of cracking (kg NH_3/m^2.s).

Given: Mwt $_{NH3}$ = 17 kg/kgmol

$N_A = 8.04 \times 10^{-4} \frac{Kmol}{m^2.s}$

$N_A = 0.0136 \frac{kg}{m^2.s}$

(35 Marks)

FACULTY OF ENGINEERING

MidTerm Examination
Academic Year 2024-2025

KOYA UNIVERSITY

Department: Chemical Engineering
Stage/ Level: 3
Total Mark: 100

Course Title: Unit Operation
Course Code: KOU20441
Time Allowed: 90 minutes
Attached Sheet: Non

Q1) A solute gas is absorbed from a dilute gas-air mixture by counter current scrubbing with a solvent in a packed tower. The equilibrium relation is **Y = m X**. If (99%) of the solute is to be recovered using a liquid rate of 1.75 times the minimum and the height of transfer unit is (1 m). What height of packing will be required?

(20 Marks)

Q2) In an experimental study of the absorption of ammonia by water in a wetted-wall column, the value of KG was found to be 2.75×10^{-6} kmol/m^2 ·s·kPa. At one point in the column, the composition of the gas and liquid phases were 8.0 and 0.115 mole % NH_3, respectively. The temperature was 300 K and the total pressure was 1 atm. Eighty-five percent of the total resistance to mass transfer was found to be in the gas phase. At 300 K, ammonia-water solution follows Henry's law up to 5 mole % ammonia in the liquid, with H = 1.64 when the total pressure is 1 atm. Calculate the individual film coefficients and the interfacial concentrations.

KoL

(20 Marks)

Q3) A soluble gas is to be absorbed from air in water in packed tower. The inlet and exit gas stream concentrations are 0.08 and 0.009 kgmole solute/kgmole air. The water enters the tower solute free and leaves with concentration 0.08 kg solute/kg water. The height of the liquid and gas phase transfer units are 0.5 m and 1 m respectively and the equilibrium relationship is given by Y*= 0.06 X. Drive an expression for the packed height in the tower and calculate the height of the packed tower.

$\left(\frac{Ls}{Gs}\right)_a$ $\quad N_{oG} = m \frac{Gs}{Ls}$

$\frac{m}{\left(\frac{Ls}{Gs}\right)_{min}}$

(25 Marks)

Q4) The gas CO_2 is diffusing at steady state through a 20 cm long tube with a diameter of 1 cm. The tube contains N_2 at 350 K and the total pressure is constant at 101.32 kPa. The CO_2

gas has a composition of 60 vol.% at one end of the tube and 10 vol.% at the other end. The diffusivity D_{AB} is 0.16 cm^2/s at 298 K.

(a) Calculate the mass rate of CO_2.

(b) If the total pressure was doubled calculate the time required for CO_2 to diffuse through the tube.

(35 Marks)

FACULTY OF ENGINEERING

MidTerm Examination
Academic Year 2021-2022

0.58123

KOYA UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport phenomena
Course Code: KOU20441
Time Allowed: 90 minutes
Attached Sheet: Non

Q1) A solute gas is absorbed from a dilute gas-air mixture by counter current scrubbing with a solvent in a packed tower. The equilibrium relation is **Y = m X**. If (99%) of the solute is to be recovered using a liquid rate of 1.75 times the minimum and the height of transfer unit is (1 m). What height of packing will be required?

(20 Marks)

Q2) Drive an expression for the diffusion of an ideal gas in unsteady state conditions.

(15 Marks)

Q3) A packed tower operating at 101 kPa, recovers 95% of solute gas initially is presented at low concentration in an inert gas. The inert gas rate is 0.16 kmol/m².s and the tower is supplied with solute free liquid at the rate of 0.23 kmol/m².s. Calculate the height of the tower given:

0.5782

$$y_A^* = 0.8 * x_A$$

$$KOG.a = 50 + KOL.a$$

Where KOG.a, and KOL.a are in kmol/m³.h

$X_a + X_B + X_C = 1 - X_a$

(30 Marks)

Q4) Ammonia is being cracked on a solid catalyst according to the reaction:

$1 - y_a = y_B$

$$2NH_3 \rightarrow N_2 + 3H_2$$

At one place in the apparatus where the pressure is 1 atm and the temperature is 200 °C the analysis of the bulk gas is 33.33% NH_3 (A), 16.67% N_2 (B), and 50% H_2 (C) by volume. The circumstances are such that NH_3 diffuses from the bulk gas stream to the catalyst and the products of the reaction diffuse back as if by molecular diffusion through a gas film in laminar flow of 1 mm thickness. The diffusion is controlled (chemical reaction very rapid) with the concentration of NH_3 at the catalyst surface equal to zero. Also at 1 atm and 200 °C, $D_{AB} = 5.39 * 10^{-5}$ m²/s, $D_{AC} = 1.66 * 10^{-4}$ m²/s. Estimate the local rate of cracking (kg NH_3/m².s).

Given: Mwt $_{NH3}$ = 17 kg/kgmol

$kgmol = \frac{kg}{M}$ kmol

kmol $n = \frac{m}{Mwl}$

$kgmol \times \frac{kg}{kgmol}$

$n = 14$

(35 Marks)

0.0001

$PV = nRT$
$P = CRT$

$\frac{t_s}{KOLa} = \frac{t_s}{KOG} \times \frac{t_s}{mG}$

6024.1

3092.2

FACULTY OF ENGINEERING

Final Examination
2018-2019

UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Unit Operation I
Course Code: UOP5521
Time Allowed: 180 minutes
Attached Sheet: Non

(a)Calculate the number of theoretical plates when L= 0.65 kg/m^2.s and G = 0.4 kg/m^2.s.

$\frac{m}{\alpha} = \frac{2}{0.8}$ 2.3

(b) Calculate (L/G) if the actual number of plates =12 and overall column efficiency = 0.5

Given: M.wt $_{NH3}$ = 17 kg/kgmol

$\alpha = \frac{0.0056}{0.1}$ $\frac{L}{G} = \frac{m}{\alpha}$ $N = 3.6 \approx 4$ stage

$\frac{2}{0.94} = 2.23$

(25 Marks)

Q5) A continuous rectifying column handles a mixture consisting of 40 per cent of benzene by mass and 60 per cent of toluene at the rate of 4 kg/s, and separates it into a product containing 97 per cent of benzene and a liquid containing 98 per cent toluene. The feed is liquid at its boiling-point.

(a) Calculate the mass flows of distillate and waste liquor.

(b) If a reflux ratio of 3.5 is employed, how many plates are required in the rectifying part of the column?

Given: M.wt $_{Benzene}$ = 78 kg/kgmol, M.wt $_{toluene}$ = 92 kg/kgmol

(25 Marks)

$x_f = \dfrac{40/78}{\frac{40}{78} + \frac{60}{92}}$

$x_d = \dfrac{97/78}{\frac{97}{97} + \frac{3}{92}}$

$x_w = \dfrac{2/78}{2/78 + \frac{98}{92}}$

Mole fraction of benzene in liquid	Mole fraction of benzene in vapour
0.1	0.22
0.2	0.38
0.3	0.51
0.4	0.63
0.5	0.7
0.6	0.78
0.7	0.85
0.8	0.91
0.9	0.96

The feed is at liquid at boiling point. The q line is a vertical line as drawn as

intercept of top operation line on the y axis is given by $\frac{x_d}{R+1} = 0.216$

Good Luck

The plate stripped off as shown as, 10 theoritical are required

FACULTY OF ENGINEERING

Final Examination
Second Attempt - 2020-2021

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

Q4) A mixture containing 52% pentane is to be distilled continuously to give a top product of 95% pentane and a bottom product of 10%. Determine the minimum number of plates by graphical and analytical methods. Also for the same conditions determine the liquid composition on the second plate from the top by using Lewis Sorel method with a reflux ratio of 2 kgmol/kgmol product.

(25 Marks)

Given:

$\alpha_{AB} = 3.47$

x	y
0.1	0.21
0.2	0.41
0.3	0.54
0.4	0.66
0.5	0.745
0.6	0.82
0.7	0.875
0.8	0.925
0.9	0.975

Good Luck

Q3) A mixture of ammonia and air is scrubbed in a plate column with fresh water. If the ammonia concentration is reduced from 5% to 0.5% and the equilibrium equation is given as $y^{*} = 2 * x$. Calculate (L/G) if the actual number of plates =12 and overall column efficiency = 0.5

(25 Marks)

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 90 minutes
Attached Sheet: Non

Q2) A species of A in a gas mixture diffuses through a 3 mm thick film and reaches a catalyst surface where the reaction below takes place:

$$A \rightarrow 2B$$

PA1 DAB

If the partial pressure of (A) in the bulk of the gas is 8.5 kN/m^2 and the diffusivity of (A) is 2 $*10^{-5}$ m^2/s, find the mole flux of (A). The pressure and temperature of the system are 101.3 kN/m^2 and 297 K respectively.

97.8

(25 Marks)

Q3) In an experimental study of the absorption of ammonia by water in a wetted-wall column, the value of KG was found to be 2.75×10^{-6} kmol/m^2·s·kPa. At one point in the column, the composition of the gas and liquid phases were 8.0 and 0.115 mole % NH_3, respectively. The temperature was 300 K and the total pressure was 1 atm. Eighty-five percent of the total resistance to mass transfer was found to be in the gas phase. At 300 K, ammonia-water solution follow Henry's law up to 5 mole % ammonia in the liquid, with H = 1.64 when the total pressure is 1 atm. Calculate the individual film coefficients and the interfacial concentrations.

(25 Marks)

Q4) Through the accidental opening of a valve water has been spilled on the floor of an industrial plant in a remote difficult area of 1 ft^2. It is desired to estimate the time required to evaporate the water in the surrounding air. The water layer is 0.04 in. thick and may be assumed to remain at a constant temperature of 75 °F and 1 atm with a molal humidity of 0.0032 lbmol H_2O/lbmol air. The evaporation is assumed to take place by molecular diffusion though a gas film 2 in. thick at 75 °F, saturated molal humidity is 0.0303 lbmol H_2O/lbmol air. The diffusivity of water vapour in air is 0.0084 ft^2/s.

Given:

$R = 0.73 \frac{atm.ft^3}{lbmol.\,^oR}$ $\qquad\qquad \rho_{water} = 62.4 \frac{lb}{ft^3}$

(35 Marks)

Q2) The gas CO_2 is diffusing at steady state through a tube 20 cm long having diameter of 1 cm and containing N_2 at 350 K. The total pressure is constant at 101.32 kPa. The partial pressure of CO_2 at one end is 456 mmHg and 76 mmHg at the other end. The diffusivity D_{AB} is 0.167 cm2/s at 298 K. Calculate the mass rate of CO_2. If the partial pressure remains constant calculate the total pressure to double the transfer rate.

Given: 1cm = 0.01 $\frac{cm^2}{s}$

M.wt$_{CO_2}$ = 44 kg/kgmol

(25 Marks)

FACULTY OF ENGINEERING

MidTerm Examination
Academic Year 2020-2021

UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 90 minutes
Attached Sheet: Non

Q1) The experimental value of the gas diffusivity of oxygen (A)/benzene (B) at 38 °C and 1atm is 0.101 cm^2/s. Estimate the diffusion coefficient for oxygen (A)/benzene (B) at 38 °C and 1 atm using the method of Fuller et al and compare it with the given experimental value. Also if the temperature was raised to 200 °C how can this affect the given experimental value of the gas diffusivity of oxygen (A)/benzene (B).

Given : $M.wt_{BZ}$ = 78 kg/kgmol

(15 Marks)

Atomic Diffusion Volumes
and Structural Diffusion-Volume Increments

C	15.9	F	14.7
H	2.31	Cl	21.0
O	6.11	Br	21.9
N	4.54	I	29.8
Aromatic ring	−18.3	S	22.9
Heterocyclic ring	−18.3		

Diffusion Volumes of Simple Molecules

He	2.67	CO	18.0
Ne	5.98	CO_2	26.7
Ar	16.2	N_2O	35.9
Kr	24.5	NH_3	20.7
Xe	32.7	H_2O	13.1
H_2	6.12	SF_6	71.3
D_2	6.84	Cl_2	38.4
N_2	18.5	Br_2	69.0
O_2	16.3	SO_2	41.8
Air	19.7		

$Na = k_{cg} y_A - k_{cg} y'$

$Na - k_{cg} y_A = -k_{cg} y'$

$-\frac{Na}{k_{cg}} + y_a = y_A'$

$S y_{A} \Delta = Da$

FACULTY OF ENGINEERING First Semester Examination 2019-2020

KOYA UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Unit Operation I
Course Code: UOP5521
Time Allowed: 90 minutes

Q3) An open bowl 0.3 m diameter contains water at 350 K evaporating into the atmosphere. If the air current is sufficiently strong to remove the water vapour as it formed ($P_{A2} = 0$) and the resistance to its mass transfer in air is equivalent to that of 1 mm thick layer for conditions of molecular diffusion, what will be the rate of cooling due to evaporation? The water can be considered as well mixed and the water equivalent in the system is equal to 10 kg. The diffusivity of water in air can be taken as 0.2 cm^2/s, and the kilogram molecular volume is 22.4 m^3.

rate of heat $= m\, C_P \frac{\Delta T}{dt}$

Given:

$P^*_{\text{water at 350 K}}$ = 41.8 kPa, latent heat of vaporization (λ) = 2466 KJ/kg,

Cp water = 4.184 KJ /kg.k

mwt
A
λ

(35 Marks)

FACULTY OF ENGINEERING

Final Examination
Second Attempt - 2020-2021

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

x_F $\quad$ x_d

Q4) A mixture containing 52% pentane is to be distilled continuously to give a top product of 95% pentane and a bottom product of 10%. Determine the minimum number of plates by graphical and analytical methods. Also for the same conditions determine the liquid composition on the second plate from the top by using Lewis Sorel method with a reflux ratio of 2 kgmol/kgmol product.

x_w $\quad$ R

(25 Marks)

Given:

$\alpha_{AB} = 3.47$

x	y
0.1	0.21
0.2	0.41
0.3	0.54
0.4	0.66
0.5	0.745
0.6	0.82
0.7	0.875
0.8	0.925
0.9	0.975

$\frac{x_d}{R+1}$ 3

Good Luck

FACULTY OF ENGINEERING First Semester Examination 2019-2020

KOYA UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Unit Operation I
Course Code: UOP5521
Time Allowed: 90 minutes

Q1)

(A) In a packed column operating at atmospheric pressure and 295 K, 10% ammonia – air mixture is scrubbed with water and the concentration is reduced to 0.1%. If the whole of the resistance to mass transfer may be regarded as lying within a thin laminar film on the gas side of the gas liquids interface, drive from the first principle an expression for the rate of absorption at any position in the column. At some intermediate point where the ammonia's concentration in the gas phase has been reduced to 5%, the partial pressure of ammonia is in equilibrium with the aqueous solution is 660 N/m^2, and the transfer flux is 10^{-3} $kgmol/m^2.s$. What is the thickness of the hypothetical gas fiim if the diffusivity of ammonia in air is 0.24 cm^2/s ?

(25 Marks)

(B) Drive an expression for the diffusion of an ideal gas in unsteady state conditions.

(15 Marks)

Q2) For a system in which component (A) is transferring from the liquid to the gas phase, the equilibrium is given by $\mathbf{y_A^* = 0.75\ X}$. At one point in the apparatus the liquid contain 90 mol% of (A) and gas contain 45 mol% of (A). The individual gas film mass transfer coefficient at this point in the apparatus of 0.02716 $kmol/m^2.s$, and 70% of the overall resistance to mass transfer is known to be encountered in the gas film: determine:

1. The molar flux of (A).

$N_A = k_g (y_{AB} - y_{Ai})$

$N_A = k_g (y_A - y_A^\circ)$

2. The interfacial concentration of (A).

3. The overall mass transfer coefficient for liquid and gas phases.

(25 Marks)

FACULTY OF ENGINEERING | **Final Examination 2018-2019** | **KOYA UNIVERSITY**

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Unit Operation I
Course Code: UOP5521
Time Allowed: 180 minutes
Attached Sheet: Non

Q1) A packed tower operating at 101 kPa, recovers 95% of solute gas initially is presented at low concentration in an inert gas. The inert gas rate is 0.16 kmol/m^2.s and the tower is supplied with solute free liquid at the rate of 0.23 kmol/m^2.s. Calculate the height of the tower given:

$y_A^* = 0.8 * x_A$

$KOG.a = 50 + KOL.a$

Where KOG.a, and KOL.a are in kmol/m^3.h

NOG = 5.05
NOL = 2.305
$NOL = \frac{1}{a} NOG$
$\boxed{Z = 11.6m}$
0.0694
3600

(15 Marks)

Q2) A Tube has 2 mm diameter and 2 cm long is closed at one end. This tube is filled with acetone to a depth of 1 cm. How long would the acetone take to evaporate completely if the tube was maintained at a temperature of 20 °C in a current of air?

Given:

$P^*_{acetone}$ = 180 mmHg, P_t = 760 mmHg, D_{AB}= 0.1 cm^2/s,

M.wt$_{acetone}$=58kg/kgmol, $\rho_{acetone}$ = 790 kg/m^3

t = 23415.33 s $= \boxed{390 \text{ min}}$

(20 Marks)

Q3) Calculate the rate of burning of a carbon particle 2.54 cm diameter in an atmosphere of pure oxygen at 1000 K and 1 atm. Drive an expression to describe the process assuming a very large blanking layer of CO_2 has formed around the particle. Given the diffusivity of oxygen in carbon dioxide is 1.032 cm^2/s, and

At the carbon surface: P_{CO2} = 1 atm $\quad$ P_{O2} = 0 atm

At very large radius: P_{CO2} = 0 $\quad$ P_{O2} = 1 atm

equation
$N_A = 9.8 \times 10^{-5}$

(15 Marks)

Q4) A mixture of ammonia and air is scrubbed in a plate column with fresh water. If the ammonia concentration is reduced from 5% to 0.5% and the equilibrium equation is given as $y^* = 2 * x$

(a) $x_1 = 0.0174$ $\quad$ $c_1 = -0.0171$

$Q = 0.775$ $\quad$ $c_2 = 0.0671$

FACULTY OF ENGINEERING

Final Examination
First Attempt - 2021-2022

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

Q1) A relatively non-volatile hydrocarbon oil contains 4 mol % propane and being stripped by direct superheated steam in stripping tray tower to reduce the propane content to 0.2 mol %. The temperature is held constant at 422 k by internal heating in the tower at a pressure of $2.026 * 10^5$ pa. Twice the minimum of direct steam is used for 300 kmol of total interning liquid. The vapour liquid equilibrium can be given by y = 25 x, where x and y are mole fractions. Determine the number of theoretical trays.

63.138

2.73×10^{-3}

−0.038

20

0.002

(25 Marks)

Q2) The gas CO_2 is diffusing at steady state through a tube 20 cm long having diameter of 1 cm and containing N_2 at 350 K. The total pressure is constant at 101.32 kPa. The partial pressure of CO_2 at one end is 456 mmHg and 76 mmHg at the other end. The diffusivity D_{AB} is 0.167 cm2/s at 298 K. Calculate the mass rate of CO_2. If the partial pressure remains constant calculate the total pressure to double the transfer rate.

Given:

1 cm = 0.01

$\frac{cm^2}{s}$

M.wt$_{CO2}$ = 44 kg/kgmol

(25 Marks)

$\frac{C}{L} = \ldots (x_1 - x_2) = C(x_1 - x_2)$

Q3) A mixture of ammonia and air is scrubbed in a plate column with fresh water. If the ammonia concentration is reduced from 5% to 0.5% and the equilibrium equation is given as $y^* = 2 * x$. Calculate (L/G) if the actual number of plates =12 and overall column efficiency = 0.5

$\frac{kmol}{hr} \times \frac{1\,hr}{3600}$

$x_1 =$

(25 Marks)

Q4) 100 Kmol/hr of a feed of 60% benzene and 40% heptane is to be separated by distillation. The distillate is to be 90 mol% benzene and the bottoms 10 mol% benzene. The feed enters the column as 30 mol% vapor. Use the reflex 1.5 times the minimum.

0.1

$D_{AB2} = \frac{D_{AB1} \cdot t_1}{P_2}$

$C_2 = -C_1$

$C_1 = 0.0$

$-C_1$

$(1+\theta)C_1$

−6.78

$\pi \; 0.2 \times 0.01$

FACULTY OF ENGINEERING

Final Examination
Second Attempt - 2020-2021

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3^{rd}
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

Q1) A gas stream contains 4 mol % NH_3 and this ammonia concentration is needs to be reduced to 0.5 mol % in a packed tower operating at 298 K and 101 kPa. The tower diameter is 750 mm.The inlet pure water flowerate is 68 kmol/h and the inlet gas flowrate is 57.8 kmol/h. The individual gas film mass transfer coefficient kg.a = 0.074 kmol/m^3.s and the individual liquid film mass transfer coefficient kl.a = 0.17 kmol/m^3.s. Calculate the height of tower if the equilibrium relationship is given as $P^*_A = 1.46\ C_A$.

(25 Marks)

$G=(Y_1-Y_2) = L(X_1-X_2)$

Q2) In a packed column operating at atmospheric pressure and 295 K, 10% ammonia – air mixture is scrubbed with water and the concentration is reduced to 0.1%. If the whole of the resistance to mass transfer may be regarded as lying within a thin laminar film on the gas side of the gas liquids interface, drive from the first principle an expression for the rate of absorption at any position in the column. At some intermediate point where the ammonia's concentration in the gas phase has been reduced to 5%, the partial pressure of ammonia is in equilibrium with the aqueous solution is 660 N/m^2, and the transfer flux is 10^{-3} kgmol/m^2.s. What is the thickness of the hypothetical gas film if the diffusivity of ammonia in air is 0.24 cm^2/s?

(25 Marks)

Q3) A 1 wt% solution of benzene in oil is to be stripped with steam at 1 atm and 100 °C to reduce the benzene content to 0.05 wt %.

0.005

(a) Calculate the steam usage per 100 kg of feed and the number of theoretical stages required for stripping tower where the steam composition is 1.8 times the minimum.

(b) If the efficiency is equal to 65% based on gas phase, calculate the actual number of trays required.

$e = 0.65$

Given: $y = 1.842\ x$

M.wt $_{oil}$ = 300 kg/kgmol, M.wt $_{benzene}$ = 78 kg/kgmol

(25 Marks)

FACULTY OF ENGINEERING

Final Examination
Second Attempt - 2020-2021

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

Q1) A gas stream contains 4 mol % NH_3 and this ammonia concentration is needs to be reduced to 0.5 mol % in a packed tower operating at 298 K and 101 kPa. The tower diameter is 750 mm. The inlet pure water flowerate is 68 kmol/h and the inlet gas flowrate is 57.8 kmol/h. The individual gas film mass transfer coefficient kg.a = 0.074 kmol/m³.s and the individual liquid film mass transfer coefficient kl.a = 0.17 kmol/m³.s. Calculate the height of tower if the equilibrium relationship is given as $P^*_A = 1.46\, C_A$.

(25 Marks)

$G = (Y_1 - Y_2) = L(X_1 - X_2)$

Q2) In a packed column operating at atmospheric pressure and 295 K, 10% ammonia – air mixture is scrubbed with water and the concentration is reduced to 0.1%. If the whole of the resistance to mass transfer may be regarded as lying within a thin laminar film on the gas side of the gas liquids interface, drive from the first principle an expression for the rate of absorption at any position in the column. At some intermediate point where the ammonia's concentration in the gas phase has been reduced to 5%, the partial pressure of ammonia is in equilibrium with the aqueous solution is 660 N/m², and the transfer flux is 10^{-3} kgmol/m².s. What is the thickness of the hypothetical gas film if the diffusivity of ammonia in air is 0.24 cm²/s?

(25 Marks)

Q3) A 1 wt% solution of benzene in oil is to be stripped with steam at 1 atm and 100 °C to reduce the benzene content to 0.05 wt %.

(a) Calculate the steam usage per 100 kg of feed and the number of theoretical stages required for stripping tower where the steam composition is 1.8 times the minimum.

(b) If the efficiency is equal to 65% based on gas phase, calculate the actual number of trays required.

$E = 0.65$

Given: $y = 1.842\,x$

M.wt $_{oil}$ = 300 kg/kgmol, M.wt $_{benzene}$ = 78 kg/kgmol

(25 Marks)

t = 10.6 min
600 s

FACULTY OF ENGINEERING

First Semester Examination
2018-2019

KOYA UNIVERSITY

Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Unit Operation I
Course Code: UOP5521
Time Allowed: 90 minutes

Q1) Hydrogen chloride is diffusing through an inert film of 1 mm thickness at 293 K and 100 kPa. Estimate the effect of increasing the pressure to 1000 kPa on the rate of diffusion if the mole fraction of the hydrogen chloride at one boundary is 20 %. Assume the concentration at the other boundary to be zero.

(25 Marks)

Q2) Ammonia is being cracked on a solid catalyst according to the reaction:

$P_{BM} = 33.4$
$D_m = 1.09 \times 10^{-4}$

$$2NH_3 \rightarrow N_2 + 3H_2$$

At one place in the apparatus where the pressure is 1 atm and the temperature is 200 ^{0}C the analysis of the bulk gas is 33.33% NH_3 (A), 16.67% N_2 (B), and 50% H_2 (C) by volume. The circumstances are such that NH_3 diffuses from the bulk gas stream to the catalyst and the products of the reaction diffuse back as if by molecular diffusion through a gas film in laminar flow of 1 mm thickness. The diffusion is controlled (chemical reaction very rapid) with the concentration of NH_3 at the catalyst surface equal to zero. Also at 1 atm and 200 ^{0}C, $D_{AB} = 5.39 * 10^{-5}$ m^2/s, $D_{AC} = 1.66 * 10^{-4}$ m^2/s. Estimate the local rate of cracking (kg NH_3/m^2.s)

Given: Mwt $_{NH3}$ = 17 kg/kgmol

$N_A = 8.04 \times 10^{-4}$ kmol/m^2.s

$N_A = 0.0136$ kg/m^2.s

(35 Marks)

Q3) A chamber, of volume 1 m^3, contains air at a temperature of 293 K and a pressure of 101.3 kN/m^2, with a partial pressure of water vapour of 0.8 kN/m^2. A bowl of liquid with a free surface of 0.01 m^2 and maintained at a temperature of 303 K is introduced into the chamber. How long will it take for the air to become 90% saturated at 293 K and how much water must be evaporated? $n_2 - n_1 = 0.002$
The diffusivity of water vapour in air is 2.4 * 10^{-5} m^2/s and the mass transfer resistance is equivalent to that of a stagnant gas film of thickness 0.25 mm. Neglect the effects of bulk flow. Saturation vapour pressure of water is 4.3 kN/m^2 at 303 K and 2.3 kN/m^2 at 293 K.

$\boxed{0.036 \text{ kg}}$

(40 Marks)

$$\frac{dn}{dt} = \frac{D \cdot C_T \cdot A\ (x_{A1} - x_{A2})}{zRT}$$

Good Luck

t = 9.97 min

$\boxed{597.84 \text{ s}}$

FACULTY OF ENGINEERING

Final Examination
First Attempt - 2021-2022

KOYA UNIVERSITY

Faculty: Engineering
Department: Chemical Engineering
Stage/ Year: 3rd
Total Mark: 100

Course Title: Transport Phenomena
Course Code: KOU20441
Time Allowed: 120 minutes
Attached Sheet: Non

Answer All Questions

(a) Calculate the mole flows of distillate and waste streams.

(b) Calculate the minimum reflex ratio.

(c) How many plates are required in the rectifying column?

Given:

x	y
0.12	0.35
0.21	0.515
0.37	0.7
0.42	0.743
0.55	0.83
0.63	0.871
0.71	0.9
0.85	0.957
0.93	0.981

Good Luck

w = 100 - D

RD + D

DR + 1