	Maharashtra Institute of Technology, Aurangabad.	Laboratory Manual
	Practical Experiment Instruction Sheet	
	EXPERIMENT TITLE: **To find out rate of diffusion of given liquid.**	

Experiment no. MIT(T)/PPE				
Class: T.Y.PPE	DEPARTMENT: Plastics and Polymer Engineering.			
LABORATORY: MASS TRANSFER		LOCATION:	PART:	PAGE:

DIFFUSION IN AIR

Aim: To find out rate of diffusion of given liquid.

Theory : (to be written by student)

Procedure :

- Fill the given solution in to a process column up to desired level.
- Switch on blower and regulate flow. (be sure that by-pass valve is open)
- Read zero reading and record it.
- Note down the the liquid level lapsed and note the time required for it.
- Repeat an experiment for different flow rates and temperature.

Observation

Sr. no.	Time (min)	Liquid level (mm)		Diffusivity
		Intial	final	

Calculations:

Where

R = gas constant ……Nm/kmol.deg.k (8.314Nm/kmol.deg.k)

P = atmospheric pressure …N/m2

PB2= atmospheric pressure…. N/m2

PB1=difference in atmospheric pressure and vapour pressure at that temperature…N/m2.

ϱ= density of liquid …kg/m3

M= Molecular weight of liquid ..m

Z1= intial level of liquid …m

Z2= final level of liquid …m

t= time for which liquid is evaporate

T= absolute temp.deg.k

Result:

Assignment:

1.Define Molecular diffusion

2.Derive equation for flux relating steady state diffusion of A in nondiffusing B in liquids

MIT Quest for Excellence	**Maharashtra Institute of Technology, Aurangabad.**	**Laboratory Manual**
	Practical Experiment Instruction Sheet	
	EXPERIMENT TITLE: **To Calculate mass transfer coefficient of vaporization of naphthalene balls in air.**	

Experiment no. MIT(T)/PPE			
Class: T.Y.PPE	DEPARTMENT: Plastics and Polymer Engineering.		
LABORATORY: MASS TRANSFER	LOCATION:	PART:	PAGE:

AIM: To calculate the mass transfer coefficient of vaporization of naphthalene balls in air.

THEORY: (to be written by student)

PROCEDURE

- Measure the dimension of naphthalene balls.
- These balls are taken in a glass tube and air is passed through it.
- Vaporization of balls takes place which gives a weight loss. Measure the weight of balls.
- Increase the flow rate of air and repeat the procedure.

OBSERVATION

- No. of balls=
- Diameter of balls =
- Diameter of tube=

OBSERVATION TABLE

Flow rate of air	Intial weight of balls	Final weight of balls	Loss in weight	Mass velocity of air	K_G	J

FORMULAE

CALCULATIONS:

Where

-dN/Dt= rate of vaporization.

A_p= surface area of solute particle
P_s=vapour pressure of solute
Partial pressure of solute=0
G=mass velocity of air = M/A
ΔWS= loss in weight gm/min
MS= molecular weight of solute=128
K_{G}= mass transfer coefficient
SC= Schmidt no.= 28
Mn= molecular weight of air.=28

Result : Mass transfer coefficient of vaporization of naphthalene balls in air is

Assignment:
1.Describe diffusion in polymers
2.Explain eddy diffusion

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Aim: To verify Rayleigh’s equation.

Theory: (to be written by student)

Procedure:

- Prepare a known binary mixture
- Note the initial weight and calculate no. of moles of each component.
- Keep the mixture in a bottom flask and connect a condenser and cooling water supply.
- Start heating till it distills $2/3^{rd}$ of it.
- Tiltrate the feed and residue with 0.5 N NaoH solution.
- Tabulate the data and prove rayleigh’s equation.

Observations:

- Volume of feed =
- Volume of residue =
- Titration reading for feed =
- Titration reading for residue =

Calculations for feed:

Calculate normality of acid by $N_1V_1 = N_2V_2$

Volume of acetic acid in feed =

Weight of acetic acid in feed =

Moles of acetic acid in feed =

Volume of water in feed =

Weight of water in feed =

Moles of water in feed =

Mole fraction of water in feed (x_F)=

Repeat the calculations for residue and calculate x_w

Calculate ln (F/W)

Plot a graph of 1/(y-x) on y axis and x on x-axis (using equilibrium data)

and calculate area under the curve from x_w to x_f.

Prove Rayleigh’s equation

Result: Thus the Rayleigh’s equation is unified as R.H.S.= L.H.S.

Assignment:

1.Define Raoults and Daltons Law

2.Derive equation to generate x-y data from relative volatility

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Aim : To find out the height equivalent to the theoretical plate for a packed column.
Chemicals : Acetic acid, Water, NaOH etc
Theory : For distillation operation, packed column are essentially useful whenever we have to carry out operation at low pressure. The ability of a given packing to affect the desired mass transfer between gas and liquid phase is usually expressed as the height equivalent to one theoretical plate (HETP). HETP is defined as the height of packing giving the enrichment of vapour same as that can be obtained by one theoretical plate.
Procedure :

1) Prepare a known mixture of acetic acid and water and charge to a batch still.
2) Insert the thermometer; connect the condenser to cooling water supply.
3) Start heating the still, carry out distillation operation.
4) Collect distillate and residue and analyze the composition.

Observation :

1) Volume of water in feed =
2) Volume of acetic acid in feed =
3) Volume of distillate =
4) Volume of residue =
5) Distillate titration reading =
6) Residue titration reading =

Calculation:

For distillate $N_1V_1 = N_2V_2$
Calculate weight of acetic acid
Calculate mole fraction of distillate (X_D)
Similarly calculate mole fraction of residue (X_W)

Formulae:

$$X = \frac{P_T - P_B}{P_A - P_B} \quad \& \quad Y = X\, P_A/P_T$$

Where, P_T - total pressure

P_A – vapor pressure of water

P_B - vapor pressure of acetic acid

$$N = \frac{\log [x_d / 1 - x_d]\ [1 - x_w / x_w]}{\log [X_{avg}]}$$

where $X_{avg} = \frac{Y/(1 - Y)}{X/(1 - X)}$

Z = height of packing

N = number of theoretical plates

H = height equivalent to theoretical plate

Result: Height equivalent to theoretical plate is ....

Assignments:

1. What are the different types of packings used in distillation columns
2. Explain the characteristics of packing

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Aim: To prepare T-X-Y diagram for a given mixture

Theory:

Procedure:

1) Prepare a binary mixture of from 0 mole % acid to 100 mole % acid.
2) Take known quantity of mixtures in the still filled with thermometer and start cooling water supply in condenser.
3) After reaching steady state, take out the sample from the still and titrate feed,distillate & residue.
4) Repeat the experiment with different feed composition.

Observation table:

1) Volume of distillate collected=
2) Volume of residue collected=
3) After analyzing the distillate, Volume of NaOH required=
4) After analyzing the residue, Volume of NaOH required=
5) Boiling point=

Calculations:

For residue, calculate normally by $N_1V_1=N_2V_2$
Calculate concentration, and (X) gms of acetic acid in residue.
Calculate volumes, moles and mole fraction of acetic acid in residue.

Calculate volumes, moles (y) and mole fraction of water in residue.
Repeat the same procedure for distillate and feed.
Prepare T-X-Y Diagram

Assignments:
1.Define dew point and bubble point temperature

Aim: To calculate the number of theoretical plates in a packed distillation column

Theory: Distillation operation can be carried out either in batch wise or continuous operation. when amount of material is small usually batch process is preferred from operation and cost point of view. Batch distillation is carried out by either keeping the reflux ratio constant or variable. When the quantity of distillate is to be kept high and constant the reflux ratio is required to be changed to achieve it.

Procedure:

feed preparation: prepare a feed of acetic acid and watch (15lit) and feed the solution to the tank

start up:

1. Feed the reboiler to 70% of the level i.e. till the whole sight glass is below the level of the liquid.
2. Adjust the feed to say value say 1 to 2 lpm.
3. Start the heater and set the temperature in the controller to a desired value .
4. Start the cooling water and adjust the watch flow rate as desired.
5. Vapours will rise and condensate will be observed in the reflux drum.
6. Maintain the reflux ratio by adjusting the flow rates.
7. Achieve the steady state maintaining the column top temperature at around 80^{o}c.
8. collect the distillate and feed analyse it by titrating against 3N NaOH solution.

Note: The liquid level in reboiler should not fall below the visibility in the sight glass i.e. the heater should be dipped always in the heater.

Calculations:

Condition of feed : cold feed

q = $c_p(T_b-T_f)$ +

$q = [C_p (T_b-T_f) + \lambda] / \lambda$

T_b=Mean boiling point of feed

λ = molar latent heat of feed
T_f = temperature of feed
C_p = specific heat of feed ,KJ/kgk
T= feed temperature
Calculate mole specific heat of feed =C_p *M_{avg}(KJ/Kmol k)
M_{avg} =Average molecular weight of feed
Slope of q line = -q/1-q
Intercept of rectifying section = x_d/R+1
Construct the theoretical stages.

Observation:

T_1=Reboiler temp =
T_2=temp of product=
T_3=temp of feed=
T_4=cooling water in temp=
T_5=cooling water out temp=
T_6=reflux temp=
Vapour temp at top column=
Volume of distillate collected=
Titration reading of distillate=
Titration reading of residue=

Result :

1. Number of theoretical plates including reboiler=
2. Number of theoretical plates required=

Assignments: 1.Explain azeotropic distillation

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Aim: To calculate the rate of drying

Theory: Drying refers to the removal of moisture of a substance by thermal means.It involves the transfer of liquid from a wet solid into a unsaturated gas phase. Heat and mass transfer occurs simulataneously. Drying involves removal of water at a temperature below boiling point.

Equation of constant rate drying:

$\Theta = (S_S/AN_c)(X_1 - X_2)$

Where S_S- mass of dry solids in kg

A- Area of drying surface in m^2

N_c- rate of drying in $kg/(m^2.h)$

Θ - time of drying in hours

X_1 – initial moisture content

X_2 – Final moisture content

Procedure:

1.Weigh known quantity of calcium carbonate sample and add sufficient quantity of water to form a paste.

2. Weigh petridish without and with sample.

3.Start the dryer with temperature around 90-100 ^{0}C.

4. Check the sample in intervals for removal of moisture.

5. Note the time of drying till formation of cracks.

Calculations:

$\Theta = (S_s/AN_c)(X_1 - X_2)$

Result: Rate of drying of the sample is ----

Assignments:

1.Define:

i Moisture content on wet basis

ii. Moisture content on dry basis

ii. Free moisture content

iii. Bound moisture

iv. unbound moisture

v. Equilibrium moisture content

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Aim: - To determine mass transfer co-efficient in packed absorption columns.

Theory: -

Procedure: -

1. Prepare around 40 liter of 0.1 N NaOH solution in feed tank.
2. This is done by dissolving 160 gm of NaOH pellets in 40 liter distilled water.
3. Ensure that clear solution is obtained and note turbidity is observed.
4. Start the compressor and after achieving sufficient pressure say 2 kg/cm^2.start the air feed in system, set the rotameter to desired value that is around 10 rpm, also start CO_2 gas and at rotameter tp 1 rpm.
5. Ensure steady state in both rotameter.
6. Start liquid feed pump and observe rotameter to desired value say 1 rpm.
7. Unreacted NaOH solution will run out from bottom and unreacted gas stream from top.
8. Steady state in all three rotameter is observed.
9. Reading in rotameters are noted.
10. Sample of outlet liquid stream is collected for analysis.
11. Repeat the experiment for different flow ranges.
12. Titrate NaOH feed against standard oxalic acid and standardize the same.
13. Titrate 10 ml of sample taken out of bottle with standard and stabilize the same.
14. Titrate 10 ml of sample taken out of bottle with standard HCl solution.
15. Note down the reading.

Observation Table:

Sr. no.	Flow rate of NaOH Lit/min.	Flow rate of air Lit/min.	Flow rate of CO_2 Lit/min.	Volume of HCl require. (ml)

Blank reading of sample (Initial sample) =
Normality of HCl taken =

Calculations:

For input $N_1V_1=N_2V_2$

For output $N_1V_1=N_2V_2$

1) Rate of absorption of CO_2 [R_{CO2}] =
2) Rate of absorption of CO_2 per unit volume of packed column =
3) Volume of CO_2 absorbed = $R_A \times$ molar volume
4) CO_2 outlet flow rate = Initial flow rate – volume of CO_2 absorbed
5) Molar flow rate of CO_2 at inlet =
6) Molal flow rate of air at inlet =
7) Mole fraction of CO_2 in inlet gas (y_1) =
8) Mole fraction of CO_2 in outlet gas(y_2)
9) G =
10) K_G =

Result: -

Mass transfer coefficient in packed column is Kg =

Assignment:

1. Derive material balance equation for an absorption column

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Aim: - To prepare ternary equilibrium curve for liquid-liquid extraction.

Theory: -

Procedure: -

1. Prepare 4 mixture of different composition of given system i.e. acetic acid, water, benzene.
2. Allow the mix to settle and separate the layer using separation funnel.
3. Note down the volume as layer and analyze it by titrating 10 ml against standard NaOH solution.
4. Repeat the experiment for 3 samples and draw the ternary diagram.

Observation table: -

Sample	Volume of H_2O rich phase	Volume of NaOH/10 ml	Volume of benzene rich phase	Volume of NaOH/10 ml

Calculations: -

$N_1V_1=N_2V_2$

Calculate the percentage of acetic acid and water in water rich phase

Calculate the percentage of acetic acid and benzene in benzene rich phase

Result: -

Hence, we have prepared ternary equilibrium curve for liquid-liquid extraction.

Assignment:

1. Define distribution coefficient
2. Explain selection criteria of solvent for extraction