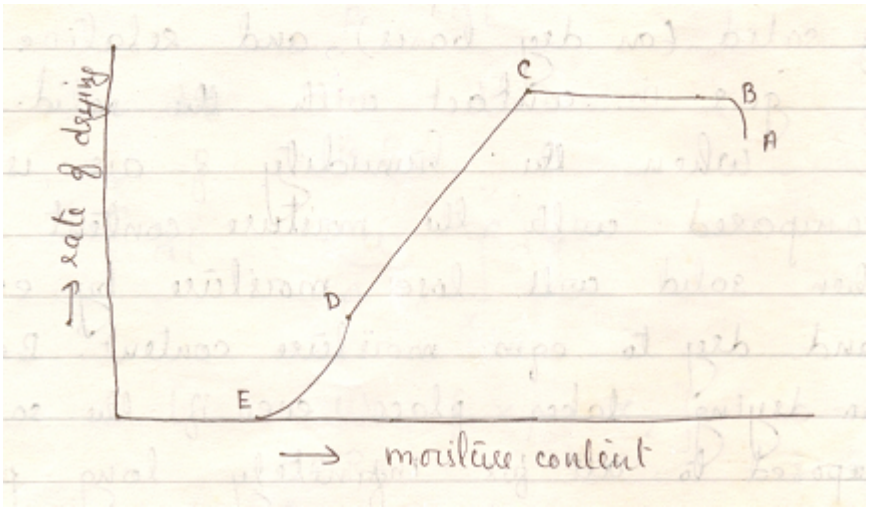
WINTER-16 EXAMINATION

Model Answer

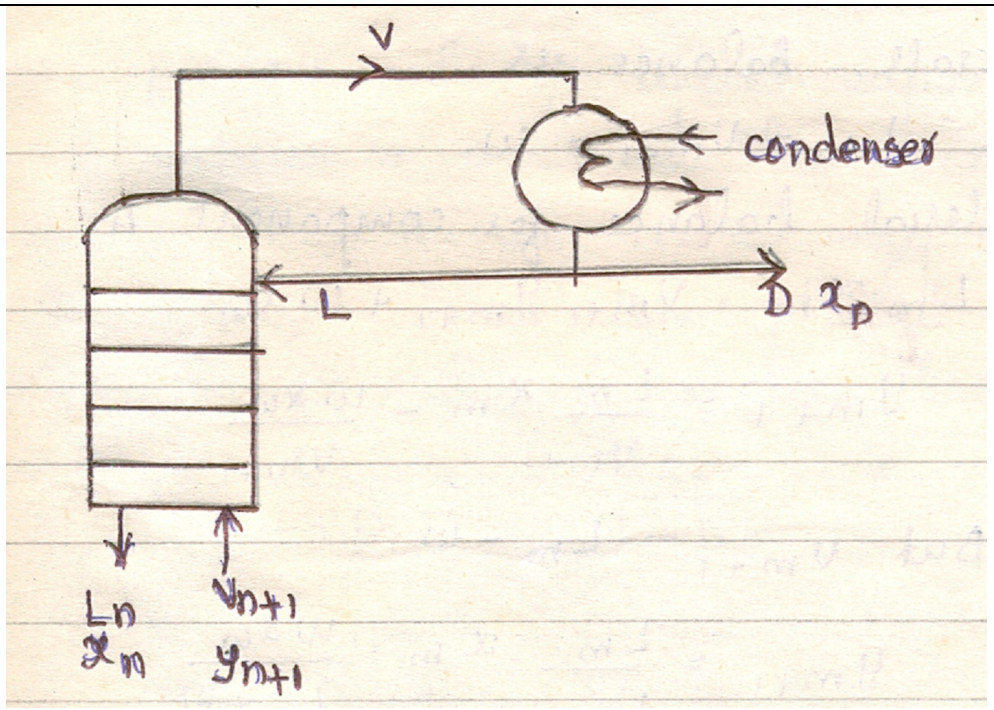
Important Instructions to examiners:

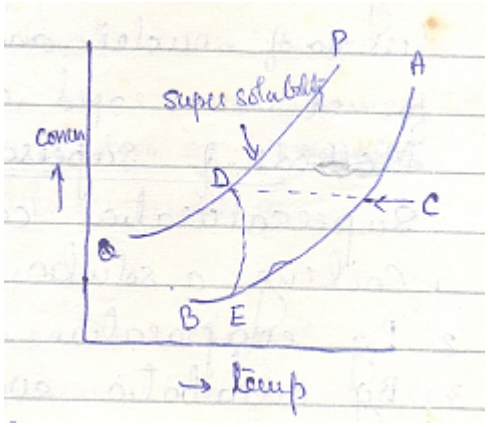
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

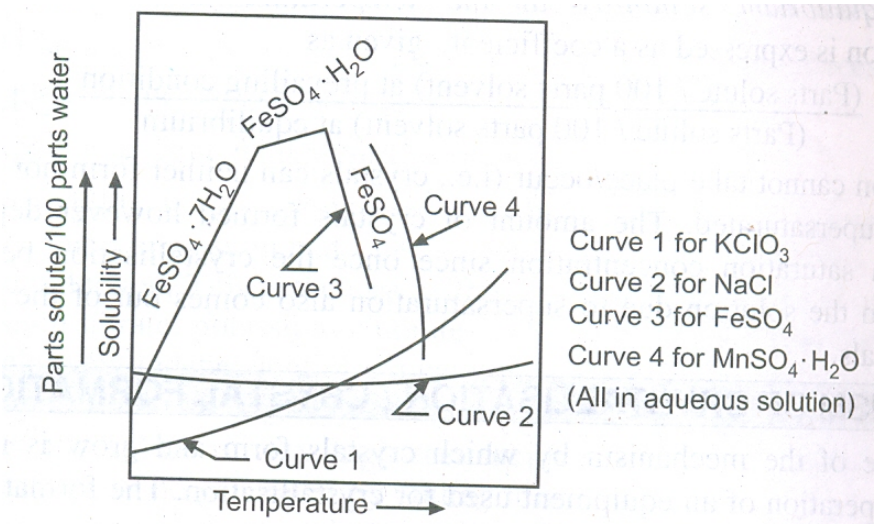
Q No.	Answer	Marking scheme
1 a	Attempt any 3	12
1a-i	**Fick's law** is the basic law of diffusion Fick's law states that the flux of a diffusing component A in z direction in a binary mixture of A and B is proportional to the molar concentration gradient. $J_A = -D_{AB}dC_A/dZ$ D_{AB} – proportionality constant, diffusion coefficient or diffusivity **Diffusivity** is defined as the ratio of the flux to the corresponding concentration gradient. It is a measure of its diffusive mobility. Diffusivity increases with decrease in pressure pressure and increases with increase in temperature.	1 1 2
1a-ii	**Raoult'slaw:**It states that at a given temperature, the equilibrium partial pressure of a component of a solution in the vapour is equal to the product of the mole fraction of the component in the liquid phase and the vapour pressure of the pure component. $P_A = P^0_A.X_A$ where P_A - partial pressure of a component P^0_A - vapour pressure of the pure component. X_A - mole fraction of the component in the liquid phase	2 2
1a-iii	**Differentiate between distillation and extraction** **Distillation** | **Extraction** Constituents of liquid mixture are separated by using thermal energy | Constituents of liquid mixture are separated by using insoluble liquid solvent	1 mark each for any 4

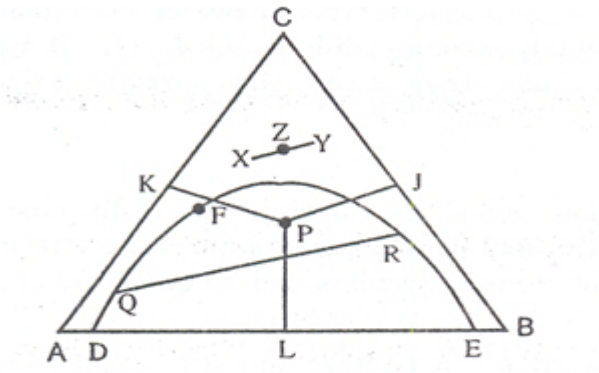
	It utilizes the difference in vapour pressure of the components to effect separation	It utilizes the difference in solubilities of the components to effect separation	
	Relative volatility is used as a measure of degree of separation	Selectivity is used as a measure of degree of separation	
	A new phase is created by addition of heat	A new insoluble liquid phase is created by addition of solvent to feed	
	Gives almost pure product	Doesn't give pure product	
	Requires thermal energy	Requires mechanical energy for mixing and separation	
	Needs heating and cooling provisions	Doesn't need heating and cooling provisions	
	Primary choice for separation	secondary choice for separation	
1.a-iv	**Rate of drying curve** :  Rate of drying curve is plotted with rate of drying on y-axis and moist. Content on x-axis. Section AB of the curve represents the warning up period during which this		1 3

	temperature of the solid is becoming equal to the temperature of drying air. BC is straight line that to x=axis in presenting constant rate of drying during which the layers of water on the surface of solid is being evaporated. The section CE of the curve represents the falling rate period composing of first falling rate period CD and second falling rate period DE from point C onwards some dry patches have started forming on the surface of the solid. The rate of drying decreases for the unsaturated portion and hence rate for total surface portion and hence rate for total surface decreases. The section CD of the curve represents the period corresponding to the zone of unsaturated surface drying the moisture content at which constant rate period ends is known as critical moisture content. After point D, the surface of the solid is completely dry and now internal movement of moistures starts coming to the surface and this is continued up to the point E, where eqm. Is attained the rate of drying over section DE is governed by the internal moisture movement.	
1b	Attempt any 1	6
1b-i	**Equation for operating line for rectifying section of distillation:**	

	 Overall balance $V_{n+1} = Ln + D$ Component balance for A $V_{n+1}\ Y_{n+1} = Ln\ Xn + DX_D$ $Y_{n+1} = Ln\ Xn / V_{n+1} + DX_D / V_{n+1}$ But $V_{n+1} = Ln + D$ $Y_{n+1} = Ln\ Xn /(L_n + D) + DX_D / (L_n + D)$ This is material balance line or operating line of rectifying section	2 4
1b-ii	**Mier's supersaturation theory:** According to Mier's theory there is a definite relationship between the conc and temp at which crystals will spontaneously formed in a pure solution. This	4

	relationship is represented by the super solubility curve which is approximately parallel tp the solubility curve. The curve AB is the solubility curve and curve PQ is the super solubility curve. The curve AB represents maximium conc of solution which can be achieved by bringing solid-solute into eqm with liquid solvent. If a solution having the composition and temp indicated by point C is cooled in the direction shown by the arrow it first crosses the solubility curve AB and it is expected to start of crystallization. Actually if the process started with initially unseeded solution crystal formation will not begin until the solution is super cooled considerably passed the curve AB. According to Mier's theory , crystallization will start in the neighbourhood of the point D and the concentration of the solution then follows roughly along the curve DE.For an initially unseeded solution , the curve PQ represents the limit at which spontaneous nuclei formation begin and consequently, crystallization can start.  	2
2	**Attempt any 4**	16
2-a	**Solubility Curves:** Graphical relationship between the solubility and temp. is solubility curve. The solubility of solute in a given solvent may increase, decrease or more or less remains constant with temp. The solubility curves of KClO3, NaCl are continuous whereas that of	2

	FeSO4, Na2SO4 are discontinuous. For some substance, their solubility decreases with increase in temp($MnSO_4H_2O$), for some solubility increases with temp($KClO_3$), for some solubility remains same with temp(NaCl).  	2
2-b	**(i) Critical moisture:** The moisture content of material at which constant rate period ends and falling rate period starts is called critical moisture content. **(ii) Equilibrium moisture content:** It is the moisture content of the substance that is in thermodynamic equilibrium with its vapour in gas phase under specified humidity and temperature of gas. It represents the limiting moisture content to which a given material can be dried under constant drying conditions.	2 2
2-c	**Triangular diagram:**	



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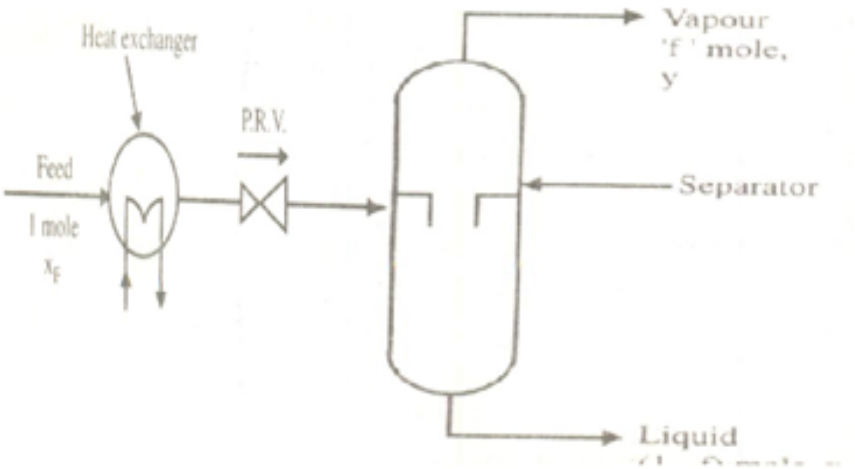
In liquid liquid extraction when the solvent is partially miscible with the original solvent , the solubility and equilibrium relations are often shown on a triangular diagram. The composition of ternary system can be shown by a point lying inside an equilateral triangle. Consider a system C (acetone).A (water),B (methyl isobutyl ketone) at 250C wherein acetone is solute , water is diluents and MIK is solvent for extracting the solute. Apex C in the triangle ABC represent 100% acetone and apex Aand B represent 100% water and 100% MIK respectively.Along line BC,concentration of Ais zero and the same is true for B and C along AC and AB.

2

The ternary system represented by point P consist of three components C,A,B in the ratio of perpendiculars PL,PJ and PK respectively.The distances AD and BE represent the solubility of solvent B in A and A in B. The curve the line ERF indicates composition of saturated MIK layer and the curve line DQF represent the composition of saturated water layer. The area under binodal solubility curve represented by the curve line DQFRE represent a two phase region that will splitup into two layers in equilibrium with each other.The point F on the curve represents a single phase which does not split into two phases and corresponds to tie line of zero length and is known as plate point.

2-d	**Flash distillation** is carried out in a continuous manner. In this method, a liquid mixture is partially vaporized the vapor and liquid are allowed to attained equilibrium and finally withdrawn separately  Consider one mole of liquid mixture having x_f mole fraction , f moles of feed that is vapourized and of composition y. Then (1-f) will be the moles of residual liquid obtained. Let x be the mole fraction of more volatile component in liquid. Material balance for more volatile component is $x_F = fy+(1-f)x$ OR **$y= -(1-f)x/f+(x_f/f)$** The above equation is operating line for flash distillation with slope = -(1-f)/f and y- intercept = x_F/f The point of intersection of operating line and diagonal (x=y) is (x_F ,x_F)	1 1 1 1
2-e	**Steam Distillation:** **Principle:** Steam distillation is adopted in cases where substance involved cannot withstand temp of distillation and decompose. Substance of this kind can be	4

	separated by reducing the partial pressure of the volatile component. This can be done by making use of inert vapour that decreases the temperature of distillation . The inert vapour used should be practically immiscible with components to be distilled. Steam is used for this purpose. In steam distillation, steam is directly admitted into the liquid in the still. The mixed vapour containing desired component is taken as overhead, condensed and desired component is separated from water phase by gravity while non volatile material remains behind in the still. **Application:** 1. For separating high boiling component from non volatile impurities. 2. For separating high boiling mixture into different fractions wherein the decomposition of material might occur if direct distillation were employed 3. Where vaporization temperature cannot be reached by heat	
3	**Attempt any 2**	16
3-a	**Solution :** Hexane is a more volatile component. α = relative volatility of hexane with respect to octane $\alpha = \frac{p^o_{Hexane}}{p^o_{Octane}} = \frac{p^o_A}{p^o_B}$ At 341.7 K, $p^o_A = 101.3$ kPa and $p^o_B = 16.1$ kPa $\therefore \quad \alpha = \frac{101.3}{16.1} = 6.29$ At 352.4 K, $p^o_A = 136.6$ kPa and $p^o_B = 23.1$ kPa $\therefore \quad \alpha = 136.6/23.1 = 5.91$	1

Similarly, evaluate α at other temperatures.

At 366.3 K, $\alpha = 5.32$

At 380.2 K, $\alpha = 4.91$

At 394.1 K, $\alpha = 4.59$

At 398.6 K, $\alpha = 4.50$

Average value of $\alpha = \frac{6.29 + 5.91 + 5.32 + 4.91 + 4.59 + 4.50}{6} = 5.25$ 2

We know that,

$$y = \frac{\alpha x}{1 + (\alpha - 1)\, x}$$ 1

Where x and y are the mole fraction of hexane in the liquid and the vapour phases, respectively.

$$y = \frac{5.25\, x}{1 + (5.25 - 1)\, x}$$

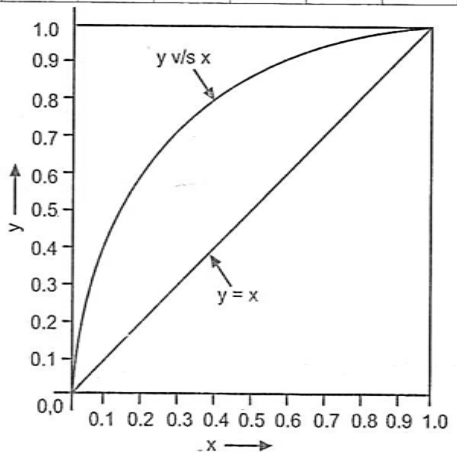
$$y = \frac{5.25\, x}{1 + 4.25\, x}$$ ... Ans. 1

Above is the desired empirical relation between y and x. Take x = 0, 0.10, 0.20….1.0 and evaluate corresponding values of y from above relation.

e.g., Take $x = 0.20$

$$y = \frac{5.25 \times (0.20)}{1 + 4.25\,(0.20)} = 0.57$$ 1

x	0.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0
y	0.0	0.37	0.57	0.69	0.78	0.84	0.89	0.92	0.95	0.98	1.0



2

3-b	Basis: 100 kmol feed D= 60, W=40 x_F=0.4 Plot 1/(y-x) vs x Ln(F/W)= ln(100/40)= 0.916 From the graph measure the area under curve from x_F=0.4 till area equals 0.916 and the corresponding value of x is noted as x_W. **x_W = 0.07** $Fx_F=Dx_D=Wx_W$ 100*0.4= 60*x_D+ 40*0.07 Solving the equation **x_D = 0.62** **Composition of distillate = 62%** **Composition of residue = 7%**	1 1 1 2 1 2
3-c	The 'q' is a measure of the thermal condition of the feed and is defined as the number of moles of saturated liquid resulting in the stripping section for each mole of feed introduced. Thus for a feed we get , L' = L + qf V = V' + (1-q)F **Derivation of q-line :** The liquid flow in the stripping section is L' = L + qf ∴ L' – L = qf ---------- (1) Similarly, the vapour flow in the rectifying section is V = V' + (1 - q) F ---------- (2)	1

	$\therefore \quad V - V' = (1 - q) F$ ---------- (3) Overall material balance in the upper section of coloumn : $V = L + D$ ---------- (4) Material balance of A in the upper section : $V_y = Lx + D\, x_D$ ---------- (5) Overall material balance in the lower section : $V' = L' - W$ ---------- (6) Material balance of A in the lower section : $V'y = L'x - W\, x_w$ ---------- (7) Subtracting Equation (7) from Equation (5) $y(V - V') = x(L - L') + D\, x_D + W\, x_w$ ---------- (8) Overall material balance of A over the coloum as a whole : $x_f . F = D\, x_D + W\, x_w$ ---------- (9) $\therefore$ Equation (8) becomes $y(V - V') = x(L - L') + x_F . F$ ---------- (10) Substituting the values of $V - V'$ and $L' - L$ from Equation (3) and (1) into Equation (10) gives $y(1 - q) F = x(-qF) + x_F . F$ $\therefore \quad y = \frac{-q}{1-q} x + \frac{XF}{(1-q)}$ ---------- (11) Equation (11) is known as the **feed line or q-line** equation	1 1 1 1 1 1 1 1
4 a	**Attempt any 3**	12

4a-i	**Selection criteria for solvent selection in liquid-liquid extraction:** 1. **Selectivity:** The ratio of concentration ratio of solute to feed solvent in extract phase to that in raffinate phase is called selectivity factor. It is the measure of effectiveness of solvent for separating the constituents. 2. **Recoverability:** As solvent should be recovered for reuse frequently by distillation, it should not form an azeotrope with extracted solute and for low cost recovery, relative volatility should be high. 3. **Distribution coefficient:** Higher values are desirable as less solvent will then be required for given extraction duty. 4. **Density:** The difference in densities of saturated liquid phases should be larger for physical separation. 5. **Insolubility of solvent:** The solvent insoluble in original liquid solvent should be preferred and it should have high solubility for solute to be extracted, then small amounts of solvent are required. 6. **Chemical Stability:** The solvent should be stable chemically and inert towards other components and should not be corrosive. 7. **Cost:** The solvent should be cheap. 8. The solvent should be non toxic, non flammable. 9. Solvent should have low viscosity, freezing point, vapor pressure for ease in handling and storage. 10. **Interfacial tension:** It should be high for coalescence of emulsions to occur more readily, as the same is of greater importance than dispersion.	1 mark each for any 4
4a-ii	**Flux equation for equimolar counter diffusion:**	

$N_A = J_A + x_A (N_A + N_B)$

$= -D_{AB} \frac{dC_A}{dz} + \frac{C_A}{C} (N_A + N_B)$ — 1

For ideal gas $P_A = C_A RT$

$C_A = \frac{P_A}{RT}$

$dC_A = \frac{dP_A}{RT}$ — 1

$C = \frac{P}{RT}$

putting values of C_A, dC_A & C

$N_A = -D_{AB} \frac{dP_A}{RT} \frac{1}{dz} + \frac{P_A/RT}{P/RT} (N_A + N_B)$

For equimolar counter diffusion, $N_A = -N_B$

$\therefore N_A = -\frac{D_{AB}}{RT} \frac{dP_A}{dz}$ — 1

if D_{AB} is constant, this can be integrated

$N_A \int_{z_1}^{z_2} dz = -\frac{D_{AB}}{RT} \int_{P_{A1}}^{P_{A2}} dP_A$

$N_A (z_2 - z_1) = -\frac{D_{AB}}{RT} (P_{A2} - P_{A1})$

$N_A z = +\frac{D_{AB}}{RT} (P_{A1} - P_{A2})$

$N_A = \frac{D_{AB}}{RTz} (P_{A1} - P_{A2})$. — 1

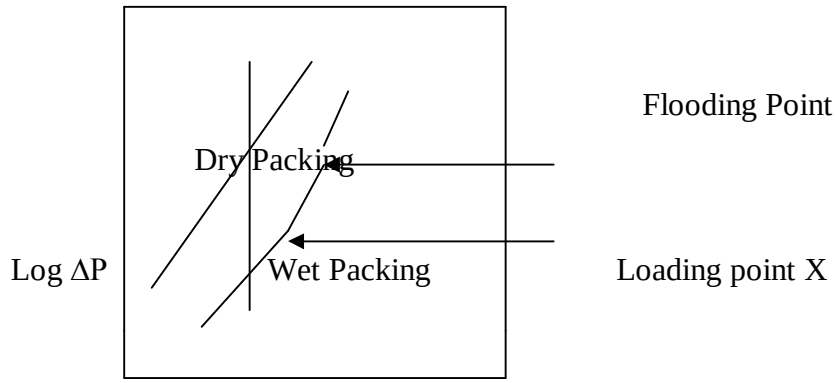
4a-iii	**Rayleigh equation:** Let F be moles of liquid mixture containing x_F mol fraction of A, D kmoles of distillate and W kmoles of residual liquid in still which are obtained at the end of operation. Let y_D and x_W be the mol fr of A in distillate and bottom residual liquid. Let L be kmoles of liquid in the still at any time during the course of distillation and let x be mol fr of A in liquid.Let very small amount dD kmol of distillate of composition y in equilibrium with the liquid is vaporized. Then composition and quantity of liquid decreases to (x-dx) and L to (L-dL) respectively. Overall material balance is L=L-dL+dD Or dL= dD Material balance for component A is Lx=(L-dL)(x-dx)+ydD Lx= Lx-Ldx-xdL+dLdx+ydD dLdx=0 0= -Ldx-xdL+ydL But dD=dL i.e. 0=-Ldx-xdL+ydL Ldx=(y-x)dL dL/L=dx/(y-x) Integrating the equation between the limits L=F, x=x_F, L=W x=x_W $\int_{W}^{F} dL/L = \int_{x_W}^{x_F} dx/(y-x)$ $\text{Ln}(F/W) = \int_{x_W}^{x_F} dx/(y-x)$	1 1 1 1

	This equation is known as Rayleigh equation.	
4a-iv	**Selection criteria for solvent in gas absorption** : While selecting a particular solvent for absorption operation , the following properties of the solvent are considered. 1) Gas solubility : the solubility of solute gas in a solvent should be high . the solvent selected should have a high solubility for the solute to be absorbed 2) Volatility : As the gas leaving an absorption unit is generally saturated with the solvent, there will be a loss of the solvent with the gas leaving the unit operation, hence to minimize the solvent loss , the solvent should be less volatile. 3) Corrosive nature : the solvent should not be corrosive towards common materials of construction so that the construction material for an absorption equipment will not be too expensive. 4) Viscosity : the solvent should have a low viscosity for rapid absorption rates, low pumping cost and better heat transfer. The solvent should be non viscous. 5) Cost and availability : the solvent should be cheap and readily available 6) Miscellaneous : the solvent should be non-toxic, non-flammable, non-foaming, and chemically stable from a handling and storage point of view.	1 mark each for any 4
4b	Attempt any 1	6
4-b i	**Hydrodynamics / pressure drop characteristics in packed column:** In a packed column there are two flows flowing in counter current direction. Liquid fed at the top of coloumn flows down the column through the void spaces in the packings, the same time gas mixture is forced up through the void spaces by using a blower or a compressor. To maintain flow of gas ,pressure at the top must be less than that at the bottom. In packed column as same channels are available for liquid down flow & gas up flow, the gas pressure drop is a	1

function of both phase flow rates & is important in design of packed column.

The variation of pressure drop with gas velocity is plotted on log-log graph as shown in fig.

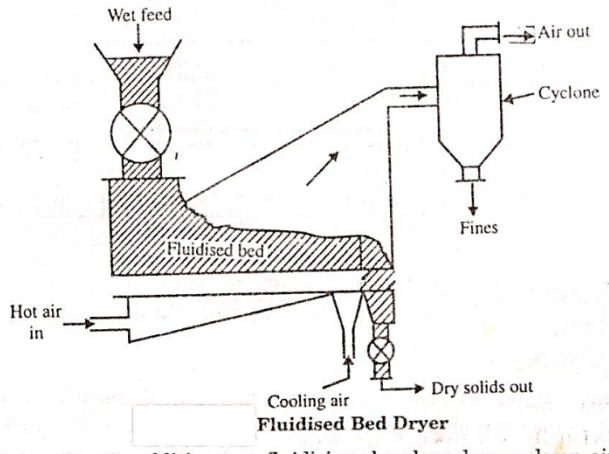
2

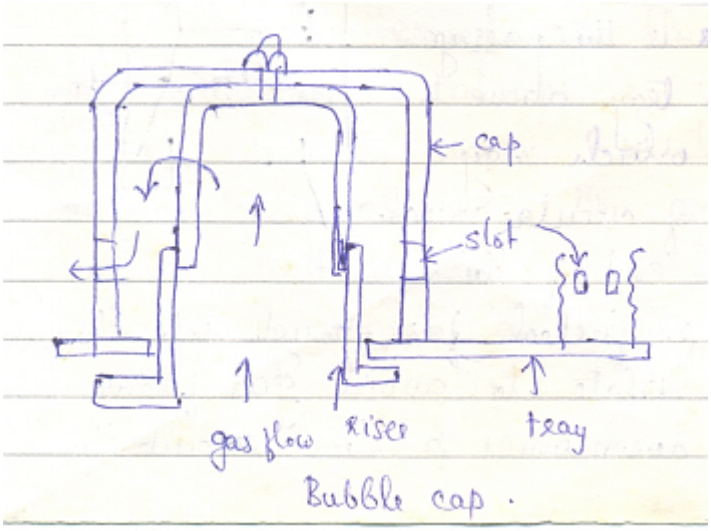


In case of dry packing, the relationship between pr.drop and gas velocity is represented by a straight line indicating that pressure drop is proportional to $G^{1.8-2}$. For wet packing, the relationship is indicated by straight line, but for a given velocity, pressure drop will be more than that for dry packing. 3

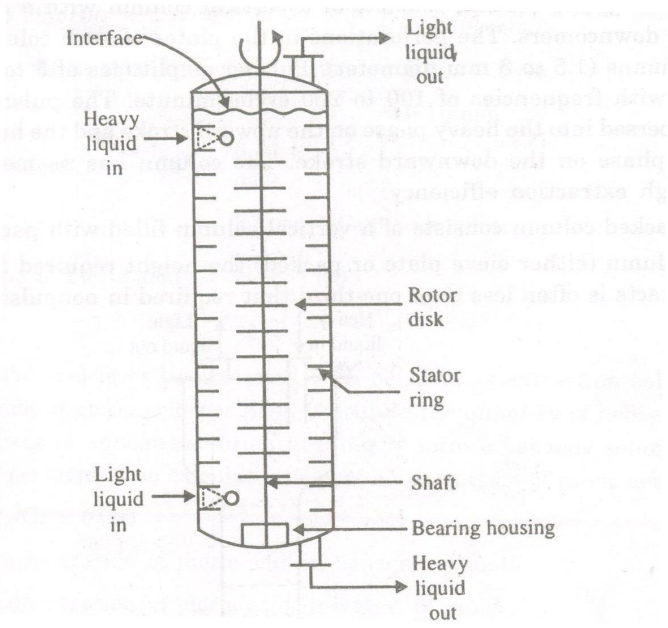
With the liquid flow down the tower at low and moderate gas velocities, pr.drop is proportional to 1.8^{th} power of gas velocity. Up to point X the amount of liquid held up in packing is constant. At point X the gas flow begins to impede the down flow of liquid and local accumulation of liquid appears here and there in packings.

As the gas velocity increases further liquid hold up progressively increases due to which free area for gas flow becomes smaller and pressure drop rises much more quickly. At gas flow rates beyond Y, pr.drop rises very steeply. At point Y, entrainment of liquid by gas leaving the top of tower increases and tower is then said to be flooded. The gas velocity corresponding to the flooding

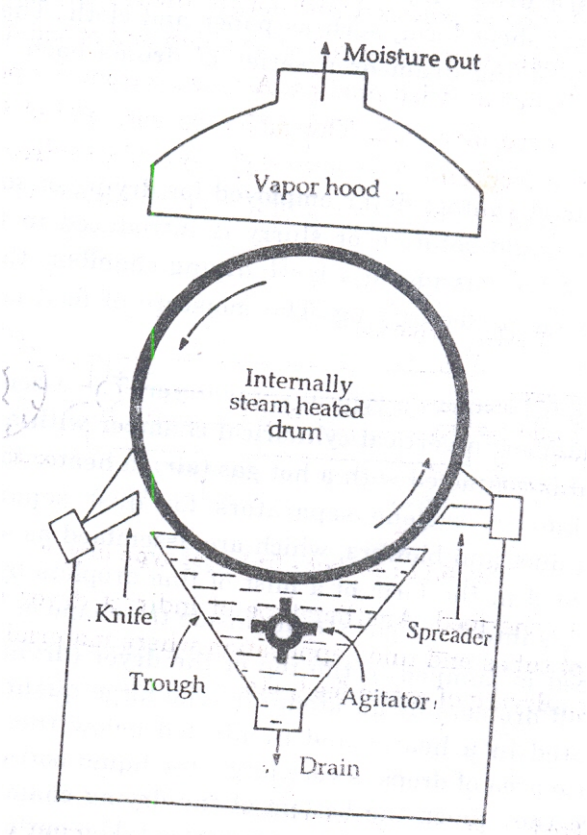
	conditions is called as flooding velocity.	
4.b ii	**Working of fluidized bed dryer**: A fluidized bed system in addition to a fluidizing chamber also needs an air blower, a hot air generator, a feed conveyor, a cyclone separator and a product conveyor. In this drier, hot air is used to keep the wet feed in a fluidized state. In the drier the wet material is dried and cooled in the same bed. Wet feed material is admitted to the top of the bed through a hopper via a rotary valve and hot air is distributed at the bottom of the bed through a diffuser plate and dry product is taken out from the side or near the bottom. Heat and mass transfer coefficient are high because of the turbulence created in the bed. The material to be dried and hot air are in cross-flow with respect to the direction of flow of each other. The residence time can be controlled from seconds to hour. The moist air from the drier containing fines is admitted to a cyclone separator for the recovery of fines. Typical velocities : Particle size (μm) Velocity (m/s) 300 – 800 0.4 to 0.8 800 – 2000 0.8 to 1.2  **Fluidised Bed Dryer** A fluidised bed system in addition to a fluidising chamber also needs an air blower, a hot air generator, a feed conveyor, a cyclone separator and a product conveyor.	3 2

	Uses: It is used for drying very fine size free flowing material. It is well suited for heat sensitive material.	1
5	Attempt any4	16
5-a	An **azeotrope** is a mixture of two or more liquids whose proportions cannot be altered by simple distillation. This happens because, when an azeotrope is boiled, the vapor has the same proportions of constituents as the unboiled mixture. The methods of separation involve introducing an additional agent, called an *entrainer*, that will affect the volatility of one of the azeotrope constituents more than another. When an entrainer is added to a binary azeotrope to form a ternary azeotrope, and the resulting mixture distilled, the method is called **azeotropic distillation**.	2 2
5-b	**Bubble cap tray**: 	4
5-c	**Comparison between packed column and plate column:** 1.Plate column operate over a wide range of liquid flow rates without flooding. 2. Plate columns by repeatedly mixing and separation provide a more positive	1 mark each for any 4

	contact between fluid phases, whereas packed columns may lead to backmixing or by passing. 3. Because of the difficulties arising in the dispersion of liquid in a packed tower, a plate tower is more reliable and needs less safety factors at low liquid to gas mass velocity ratios. 4. Side streams are very easily taken out from plate towers but not in packed towers. 5. For plate towers, design information is generally more readily available 6. Whenever liquid mixtures containing dispersed solids are to be handled, plate towers should be preferred. 7. Whenever inter stage cooling is required, plate towers are preferred. 8. For liquids having tendency to foam, packed towers are preferred 9. Pressure drop through packed tower is low. 10. The liquid hold up is low in packed tower. 11. For a given duty, total weight od dry plate tower is less than the weight of packed tower. ***As question is incomplete, comparison between plate column and packed column is given***	
5-d	Basis: 1kmol of feed. XF = mole fraction of hexane in the feed = 60/100=0.60 Feed is 50 mole% vaporized f= 50/100=0.5 The operating line for flash distillation is Y=-((1-f)/f)X+XF/f Slope= -(1-f)/f = -(1-0.5)/0.5 = -1 The point of intersection of the operating line with the diagonal ia (0.6,0.6).	1 1 1

	Draw the equilibrium curve and draw the operating line with the slope to -1 passing through (0.6,0.6) on the diagonal. It intersects the equilibrium curve at P which gives us the equilibrium liquid and vapour compositions as **0.41** and **0.79** mole fraction hexane respectively.	1
5-e	**Rotating disk contactor:** Rotating disk contactor is a mechanically agitated counter current extractor wherein agitation is brought with the help of rotating disk which usually runs at much higher speed than turbine type impeller.	2
	 **Rotating disc contactor for light phase dispersed**	2
	It consists of a cylindrical column that is divided into a number of compartments formed by a series of stator rings. Each compartment contains centrally located horizontal rotor disk that create high degree of turbulence inside the column. The diameter of the rotor disk is less than the opening in the stationery stator rings, usually the disk diameter is 33 to 66 % of the column diameter. Recommended compartment height for column of diameter 2 m is	

	200 to 300 mm. The tower is provided with inlet & outlet connections at top & bottom from light and heavy phases. Fig. represents rotating-disk contactor for light phase dispersed. In these units, disk disperse the liquids and impel them outward towards tower wall, where stator rings create quiet zones where in the two phases can separate. It has reasonable capacity, low operating cost and high efficiency. While dealing with corrosive liquids it is very difficult to maintain the internal moving arts.	
6	Attempt any 2	16
6-a	Solubility of $Na_2S_2O_3$ is 70 parts per 100 parts water at 293 K(20^0 C) Basis: 100 kg of feed solution. It contains 48 kg $Na_2S_2O_3$ and 52 kg 0f water. Let 'C' be the yield of crystals. M1 = Molecular weight of $Na_2S_2O_3$ = 158 M2 = Molecular weight of $Na_2S_2O_3, 5H_2O$ =248 XF'=48/100 = 0.48 Material balance of water : Water in feed = Water of crystallization in crystals + Water in mother liquor. 52 = C.((M2-M1)/M2) + L' L'= 52 – C[248-158]/248 Material balance of solute: Solute in feed = Solute in crystals produced +Solute in mother liquor 0.48x100 = c(158/248)+[52-((248-158)/248)C]X' 48= 0.637C+[52-0.363C]x(70/100) C=**30.3 kg**. Crystals in feed solution =48 x (248/158)= 73.34 kg % yield of hydrated crystals= (30.3/73.34) = **41.31**	1 1 1 1 1 1 1 1

6-b	Initial moisture content $X_1 = 0.67/(1-0.67) = 2.03$	1
	Final moisture content $X_2 = 0.25/(1-0.25) = 0.333$	1
	Critical moisture content $X_c = 0.4/(1-0.4) = 0.67$	1
	Equilibrium moisture content $X^* = 0.01/(1-0.01) = 0.0101$	1
	$R_C = 1.5$ Kg/m^2 hr	
	$A/W^1 = 0.5$ or $W^1/A = 2.0$	1
	$t = W^1/AR_c\{(X_1-Xc) + (X_C- X^*)\ln[(X_C - X^*) / (X_2-X^*)]\}$	1
	$t = 2/1.5\{(2.03-0.67)+(0.67-0.0101)\ln[(0.67-0.0101) / (0.333-0.0101)]\}$	
	= **2.44 hr**	2
6-c	**Drum dryer**  **Working :**	4

	A slowly revolving internally steam heated drum continuously dips into a drum and picks up the feed which retains on the drum surface as a thin film. The thickness of this film of material is regulated by means of a spreader. During the course of revolution of the drum the material is dried due to heat transfer from condensing steam through the metal wall of the drum and large surface area. As it reaches the other end the dried product of operation is scraped by knife. The moisture evaporated from the feed material is collected and removed through a vapour hood provided above the drum.	4