



WINTER-15 EXAMINATION
Model Answer

Subject code :(17648)

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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.



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Q No.	Answer	marks	Total marks
1a-i	<p>Fick's law is the basic law of diffusion</p> <p>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.</p> $J_A = -D_{AB}dC_A/dZ$ <p>Where J_A- molar flux of A in z direction C_A – concentration of A dC_A/dZ – concentration gradient in z direction D_{AB} – proportionality constant, diffusion coefficient Z – distance in the direction of diffusion</p>	2 2	4
1a-ii	<p>An azeotrope is a mixture of two or more liquids whose proportions cannot be altered by simple <u>distillation</u>. This happens because, when an azeotrope is boiled, the vapor has the same proportions of constituents as the unboiled mixture.</p> <p>Other methods of separation involve introducing an additional agent, called an <i>entrainer</i>, that will affect the <u>volatility</u> 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.</p>	2 2	4
1a-iii	<p>Selection criteria for solvent selection in liquid-liquid extraction:</p> <p>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.</p>	1 mark each for any 4	4



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	<p>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.</p> <p>3. Distribution coefficient: Higher values are desirable as less solvent will then be required for given extraction duty.</p> <p>4. Density: The difference in densities of saturated liquid phases should be larger for physical separation.</p> <p>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.</p> <p>6. Chemical Stability: The solvent should be stable chemically and inert towards other components and should not be corrosive.</p> <p>7. Cost: The solvent should be cheap.</p> <p>8. The solvent should be non toxic, non flammable.</p> <p>9. Solvent should have low viscosity, freezing point, vapor pressure for ease in handling and storage.</p> <p>10. Interfacial tension: It should be high for coalescence of emulsions to occur more readily, as the same is of greater importance than dispersion.</p>		
1a-iv	<p>Classification of dryers:</p> <ol style="list-style-type: none">1. Mode of operation: Batch dryer and continuous dryer2. Physical properties and handling characteristics of the material:3. Mode of heat transfer: Direct dryer and indirect dryer	4	4
1b-i	<p>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 ,</p>		6



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<p style="text-align: center;">$L' = L + qf$</p> <p>$V = V' + (1-q)F$</p> <p>Derivation of q-line :</p> <p>The liquid flow in the stripping section is</p> <p style="text-align: center;">$L' = L + qf$</p> <p>$\therefore L' - L = qf$ ----- (1)</p> <p>Similarly, the vapour flow in the rectifying section is</p> <p style="text-align: center;">$V = V' + (1 - q) F$ ----- (2)</p> <p>$\therefore V - V' = (1 - q) F$ ----- (3)</p> <p>Overall material balance in the upper section of columnn :</p> <p style="text-align: center;">$V = L + D$ ----- (4)</p> <p>Material balance of A in the upper section :</p> <p style="text-align: center;">$V_y = Lx + D x_D$ ----- (5)</p> <p>Overall material balance in the lower section :</p> <p style="text-align: center;">$V' = L' - W$ ----- (6)</p> <p>Material balance of A in the lower section :</p> <p style="text-align: center;">$V'y = L'x - W x_w$ ----- (7)</p> <p>Subtracting Equation (7) from Equation (5)</p> <p style="text-align: center;">$y (V - V') = x (L - L') + D x_D + W x_w$ ----- (8)</p> <p>Overall material balance of A over the coloum as a whole :</p> <p style="text-align: center;">$x_f \cdot F = D x_D + W x_w$ ----- (9)</p> <p>\therefore Equation (8) becomes</p>	2	
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	$y (V - V') = x (L - L') + x_F. F \quad \text{----- (10)}$ <p>Substituting the values of $V - V'$ and $L' - L$ from Equation (3) and (1) into Equation (10) gives</p> $y (1 - q) F = x(-qF) + x_F. F$ $\therefore y = \frac{-q}{1-q} x + \frac{XF}{(1-q)} \quad \text{----- (11)}$ <p>Equation (11) is known as the feed line or q-line equation</p>	1	
1b-ii	<p>Different methods of obtaining super saturation</p> <p>i) By cooling a concentrated, hot solution through indirect heat exchange.</p> <p>ii) By evaporating a part of solvent/ by evaporating a solution.</p> <p>iii) By adiabatic evaporation and cooling.</p> <p>iv) By adding a new substance which reduces the solubility of the original solute, i.e. by salting.</p> <p>When solubility of the solute increases with increase in temperature, super saturation is achieved by cooling. When solubility is independent of temperature, super saturation is generated by evaporating a part of solvent. When solubility is very high, super saturation may be generated by adding new substance. Original solvent to form mixed solvent in which the solubility of the solute is reduced. The added component may get mixed physically with</p>	4	6
2-a	<p>Solubility Curves:</p> <p>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.</p> <p>The solubility curves of $KClO_3$, $NaCl$ are continuous whereas that of $FeSO_4$, Na_2SO_4 are discontinuous.</p>	4	4



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	For some substance, their solubility decreases with increase in temp, for some solubility increases with temp, for some solubility remains same with temp.		
2-b	<p>Factors on which the rate of drying depends:</p> <ol style="list-style-type: none"> 1) Gas Velocity: When the velocity of the gas or air is high the rate of drying will also be high. 2) Humidity of gas : Lesser the relative humidity, the more will be the rate of drying. 3) Area of drying surface: If the area of the wet surface exposed to the gas or air is more, the rate of drying will also be more. 4) Temperature: If the temperature of the gas is increased' it's relative humidity decreases (i.e gas becomes more unsaturated) and thus increase a driving force (i.e the concentration difference of moisture between the solid and gas) and so the rate of drying increases. 	1 1 1 1	4
2-c	<p>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</p> $x_F = fy + (1-f)x$ <p>OR $y = -(1-f)x/f + (x_f/f)$</p> <p>The above equation is operating line for flash distillation with slope = $-(1-f)/f$ and y- intercept = x_F/f</p> <p>The point of intersection of operating line and diagonal ($x=y$) is (x_F, x_F)</p>	2 2	4
2-d	<p>Rayleigh equation:</p> <p>Let F be moles of liquid mixture containing x_F mol fraction of A, D kmoles of</p>	1	4



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	<p>distillate and W kmols 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.</p> <p>Let L be kmols 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.</p> <p>Overall material balance is $L=L-dL+dD$</p> <p>Or $dL= dD$</p> <p>Material balance for component A is $Lx=(L-dL)(x-dx)+yD$</p> <p>$Lx= Lx-Ldx-xdL+dLdx+yD$</p> <p>$dLdx=0$</p> <p>$0= -Ldx-xdL+ydL$</p> <p>But $dD=dL$</p> <p>i.e. $0=-Ldx-xdL+ydL$</p> <p>$Ldx=(y-x)dL$</p> <p>$dL/L=dx/(y-x)$</p> <p>Integrating the equation between the limits $L=F, x=x_F, L=W, x=x_W$</p> $\int_F^W \frac{dL}{L} = \int_{x_F}^{x_W} \frac{dx}{(y-x)}$ <p>$\ln(F/W) = \int_{x_F}^{x_W} \frac{dx}{(y-x)}$</p> <p>This equation is known as Rayleigh equation.</p>	<p>1</p> <p>1</p> <p>1</p>	
2-e	Differentiate between distillation and extraction		4



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	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 four
	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	
3-a	<p>More volatile component is n-haptane (A).</p> <p>$x = x_A =$ Mole fraction of a- haptane is liquid</p> <p>$y = y_A =$ Mole fraction of n- haptane in vapour.</p> <p>We can compute vapour –liquid composition using following relationship</p> $x = \frac{P - P_B}{P_A - P_B} \quad \text{-----} \quad 1.$ $y = P_A \cdot x$		
			8



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	<p>2.</p> <p>p</p> <p>P = 101.325 kpa , P_A= 101.325 kpa, P_B= 41.390</p> <p>T = 371.4k</p> $x = \frac{101.325 - 44.396}{101.325 - 44.396} = 1$ $y = \frac{101.325 \times 1}{101.325} = 1$ <p>At 378 k,</p> <p>P = 101.325kpa, P_A° = 125.323kpa & P_B° = 55.595 kpa</p> $x = \frac{101.325 - 55.595}{125.323 - 55.595} = 0.656$ $y = \frac{125.323 \times 0.656}{101.325} = 0.810$	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>2</p>							
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Temp k.</th> <th style="width: 25%;">X</th> <th style="width: 25%;">y</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">371.4</td> <td style="text-align: center;">1.0</td> <td style="text-align: center;">1.0</td> </tr> </tbody> </table>	Temp k.	X	y	371.4	1.0	1.0		
Temp k.	X	y							
371.4	1.0	1.0							



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	<table border="1"><tr><td>378</td><td>0.656</td><td>0.810</td></tr><tr><td>298.6</td><td>0.0</td><td>0.1</td></tr></table> <p>OR</p> <p>Total pressure = partial pressure of heptane + partial pressure of octane</p> <p>Partial pressure = Mole fraction \times Vapour pressure</p> <p>Let, 'x' is mole fraction of heptane</p> $101.325 = 101.325x + 44.396(1-x)$ $= 101.325x + 44.396 - 44.396x$ $101.325 - 44.396 = (101.325 - 44.396)x$ $X = 1$ $\& \quad y = \frac{P_A X}{P} = \frac{101.325 \times 1}{101.325}$ $= 1$ <p>Similarly all other values of x & y can be calculated.</p>	378	0.656	0.810	298.6	0.0	0.1		
378	0.656	0.810							
298.6	0.0	0.1							
3-b	<p>Basis : 60 mole % of benzene</p> $x_f = 0.6$ $x_D = 0.95$ $x_w = 0.1$	2	8						



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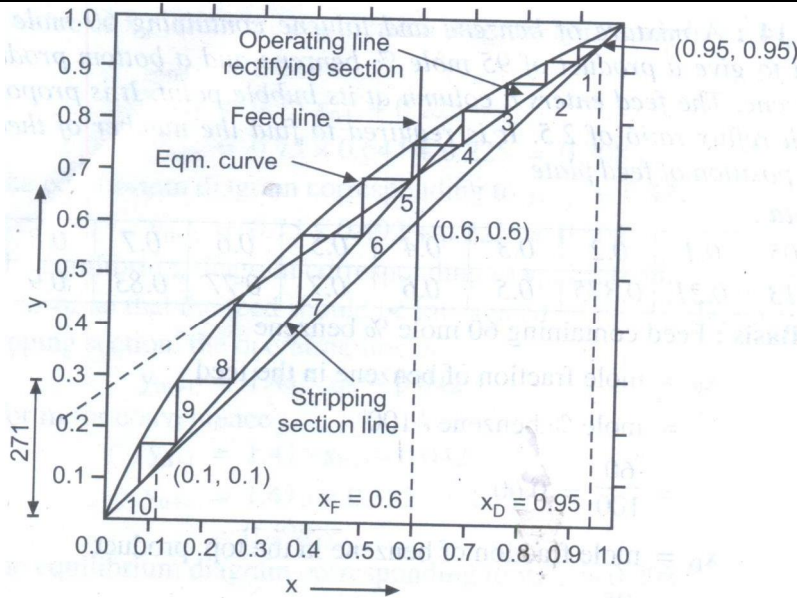


Fig. Ex 2.14 : Equilibrium diagram

intercept of operating line of rectifying section : X_D _____

$$R + 1$$

$$= \frac{0.95}{2.5 + 1}$$

$$= \frac{0.95}{3.5}$$

$$= 0.271$$

Draw operating line of rectifying section by joining (X_D, X_D)

i. e. $(0.95, 0.95)$ on diagonal to point 0.271 on y axis

As liquid is all at its bubble point draw feed line parallel to y axis through point

1

1

1



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	<p>(X_F, Y_F) on diagonal. Draw feed line (q line) through point (0.6,0.6) to meet operating line rectifying section at some point. Locate (X_W, Y_W) i. e. (0.1,0.1) on diagonal & join this point to intersection of operating line of rectifying section & feed line (q-line) This is operating line of stripping section Construct stages step by step & count them as shown in diagram. Number of ideal slages = 10 Actual no. of stages required = 10 - 1 = 9 Position of feed plate = 5th from top.</p>	<p>1 1 1</p>	
<p>3-c</p>	<p>Lewis sorel method of determination of number of theoretical plates/ slags Equation of operating line of rectifying</p> $y_{n+1} = \frac{L_n}{L_n + D} x_n + \frac{D \cdot X_D}{L_n + D} \quad \text{eq.1}$ <p>Operating line of stripping section</p> $y_{m+1} = \frac{L_m}{L_m - W} x_m - \frac{W \cdot X_W}{L_m - W} \quad \text{eq.2}$ <ol style="list-style-type: none"> 1. From the data cited in a given problem, evaluate the terms – D,W,L,etc. 2. From the x-y data provided (or can be generated knowing the relative volatility) draw an equilibrium diagram. 3. Substistute the values of $L_n(L)$, x_D, D in equation(1), in order to get a relationship between y_{n+1} and x_n. 4. Similarly ,substitute the values L_m, W, x_W in equation(2) , to get a 	<p>2 2 4</p>	<p>8</p>



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	<p>relationship between y_{n+1} and x_m. L_m is to be evaluated by taking into consideration the condition of feed. For example, if it is a liquid at its bubble point $L_m = L_n + F$.</p> <p>5. The distillate composition (x_D) given in the problem statement represents the composition of vapour (y_n) as it is obtained by condensing the vapour leaving the column.</p> <p>6. From the vapour phase composition : $y_n = x_D$, find the liquid phase composition x_{n+1} from the x-y curve drawn and substitute the value of x_{n+1} in the equation of the operating line of the rectifying section to get y_2</p> <p>7. Find x_{n+2} value from the equilibrium diagram corresponding to y_{n+2}</p> <p>8. Find y_{n+3} and proceed with the same equation till we reach the point when the liquid phase composition equal to or less than x_F</p> <p>9. Then make use of the material balance equation or operating line of stripping section and proceed in the same way as described above till we get the liquid phase composition equal to or below x_w, suppose we end with y_{n+10}, it means that there will be 10 plates in the column.</p>		
4a-i	<p>I. Applications of extraction:</p> <ol style="list-style-type: none">1. Recovery of acetic acid from dilute aqueous solution.2. Recovery of long chain fatty acid from vegetable oil by liquid propane.3. Separation of petroleum products having approximately same boiling point4. Recovery of penicillin from the fermentation both using butyl	1 mark each	4



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	acetate.		
4a-ii	<p>As the temperature & total pressure P is constant throughout, the net moles of A diffusing to the right must be equal to net moles of B diffusing to the left .if this is not so , the total pressure would not remain constant throughout the system .This implies that ,</p> $J_A = - J_B \quad \text{----- eq.1}$ <p>J_A is the molar flux of component A in the X direction due to the molar diffusion in kmol/(m².s)</p> <p>Fick's law for component B for constant molar concentration,C,becomes</p> $J_B = -D_{BA} \frac{d_{CB}}{dX} \quad \text{----- eq.2}$ <p>Here flux is in the X-direction</p> <p>According to the Dalton's law, the total pressure is the sum of the partial pressures of A & B</p> $P = p_A + p_B \quad \text{----- eq.3}$ <p>And we know that : $P_A \propto C_A$ ----- eq.4</p> <p>The total molar concentration for the gaseous mixture is given by</p> $C = C_A + C \quad \text{----- eq.5}$ <p>Differentiating both the sides of eq.5 with respect to X gives</p> $0 = \frac{d_{CA}}{dX} + \frac{d_{CB}}{dX} \quad \text{----- eq.6}$ <p>or</p> $\frac{d_{CA}}{dX} + \frac{d_{CB}}{dX} \quad \text{----- eq.7}$	1	4
		1	
		1	



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	<p>if gradient exists in a gas A, a gradient also exists in a gas B.the gradient of B is equal but opposite in sign to that of A</p> <p>Fick's law for component A for constant total concentration is</p> $J_A = -D_{AB} \frac{d_{CA}}{d_X} \quad \text{----- eq.8}$ <p>Combining equations 1, 2& 3 we get,</p> $J_A = - D_{AB} \frac{d_{CA}}{d_X} \quad \text{----- eq.9}$ $=J_B = - [- D_{BA} \frac{d_{CA}}{d_X}] \quad \text{----- eq.10}$ $-D_{AB} \frac{d_{CA}}{d_X} = D_{BA} \frac{d_{CB}}{d_X} \quad \text{----- eq.11}$ <p>but</p> $\frac{d_{CA}}{d_X} = - \frac{d_{CB}}{d_T} \quad \text{----- eq.12}$ $D_{AB} = D_{BA}$	1	
4a-iii	<p>Milk powder – Spray dryer</p> <p>Reason: Milk can be sprayed in form of fine spray in hot & dry air in counter</p>	<p>½</p> <p>½</p>	4



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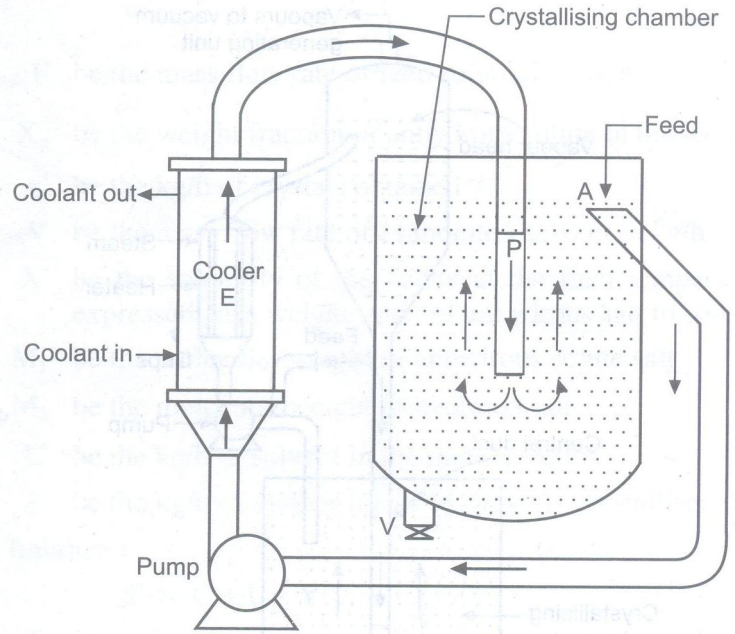
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	<p>current direction in spray chamber to get dried milk powder.</p> <p>Free flowing material – Rotary dryer</p> <p>Reason : Free flowing material is allowed to flow down in a slightly inclined cylinder which is rotating material fed is advanced through dryer by gravity in opposite direction to hot air/ flue gases admitted at bottom to flow towards top of cylinder. Spirial flights help to keep material in suspension in flow of hot & dry air.</p> <p>Wet lumpy solids – Tunnel dryer</p> <p>Reason : Wet lumps can be placed on trays which can be loaded on trucks which can be put in tunnel in which hot air is flowing in counter current direction.</p> <p>Pharmaceutical products – Tray dryer</p> <p>Reason : relatively cheap, low maintainance cost , no loss of product during drying , Easy in cleaning.</p>	<p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>	
4a-iv	<p>Let X_A & y_A be mole fraction of methyl alcohol in liquid & vapour phase</p> $P_A = P X_A$ <p>Partial pressure = vapour pressure \times mole fraction</p> <p>Of A</p> $P_B = P_B \times X_B$ $= 12.33 (1 - X_A)$ $P = P_A + P_B$ $40 = 53.32 X_A + 12.33 (1 - X_A)$ $X_A = 0.675$ $y_A = \frac{P_A}{P}$	<p>2</p>	<p>4</p>



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	<p>P</p> $= \frac{53.32 \times 0.675}{40}$ <p>= 0.90</p> <p>Equilibrium composition</p> <p>Liquid Phase = 0.675 mole fraction methane</p> <p>Vapour Phase = 0.90 mole fraction methane</p>	2	
4b-i	 <p>Fig. 6.6 : Oslo / Krystal Cooling Crystalliser</p> <p>Construction :</p> <p>It consist of a crystallizing chamber, a circulating pump and a external cooler for cooling the solution. It is a circulating liquid cooling crystalliser.</p> <p>Working :</p> <p>The solution to be crystallized is fed from the top. Mother liquor from a crystallizing chamber is withdrawn near a feed point 'A' with the help of a</p>	2	6



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	<p>circulating pump and it is then admitted to a cooler (E) wherein supersaturation is achieved by cooling. The supersaturated solution from the cooler is finally fed back to the bottom of the crystallizing chamber through a central pipe (P). Usually, nucleation takes place in the bed of crystals in the crystallising chamber. The nuclei formed circulate with mother liquor and once they go sufficiently large, they will be retained in the fluidised bed. Once the crystals grow to a required size, they are removed as product from the bottom of the crystallising chamber through a valve 'V' as these cannot be retained in the fluidised bed by the circulation velocity.</p>		
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4b-ii

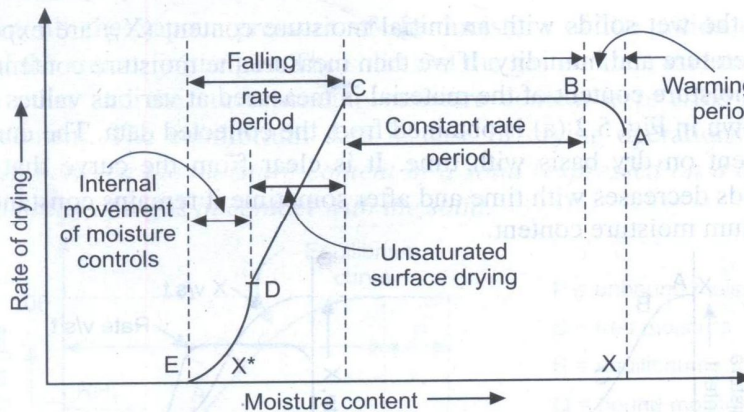


Fig. 5.3 : Typical rate of drying curve under constant drying conditions

The rate of drying curve consists of two parts :

- 1) A constant rate period, wherein the rate of drying is constant.
- 2) A falling rate period wherein the rate of drying is falling.

The section AB of the curve represents the warming up period. The section BC is called the constant rate period during which the layer of water on the surface of solid is being evaporated. The rate of drying is constant from B to C as the drying takes place from a saturated surface. The section (CE) of the curve represents the falling rate period composed of the first falling rate period (CD) and the second falling rate PERIOD (DE). From point 'C' onwards some dry

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4

2



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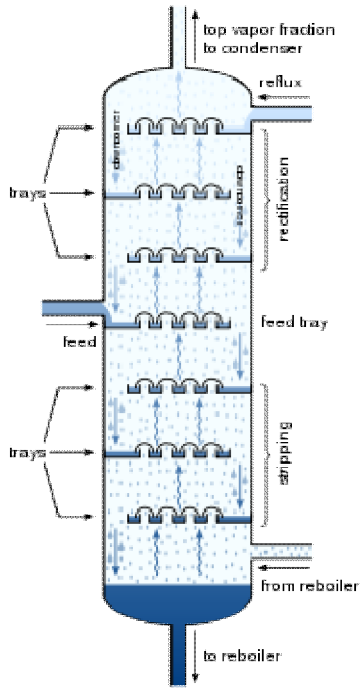
	<p>patches start forming on the surface of solid. The moisture content at which the constant rate period ends and the drying rate starts to fall is known as the critical moisture content. After point 'D' , the surface of the solid is completely dry and internal moisture starts coming to the surface and this is continued upto the point 'E' where the equilibrium is attained.</p>		
5-a	<p>Bubble cap plate is one of the devices in large diameter fractional distillation columns that are designed to produce a bubbling action to exchange the vapour bubbles flowing up the column.</p> <p>A metal cap covering a hole in <u>the</u> plate within a distillation tower; designed to permit vapors to rise from below the plate, pass through the cap, and make contact with liquid on the plate.</p> <p>The gas flow up through the riser, reverse flow under the cap, passes downward through the annulus between the riser and the cap.</p> <p>Because of cost and complexity most modern design favours sieve or valve tray over the bubble cap tray. It is specially used when</p> <ol style="list-style-type: none">Very low vapour rate to be handledAdequate residence time is required for separation	2	4
		2	



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5-b

Rectification on ideal plate:

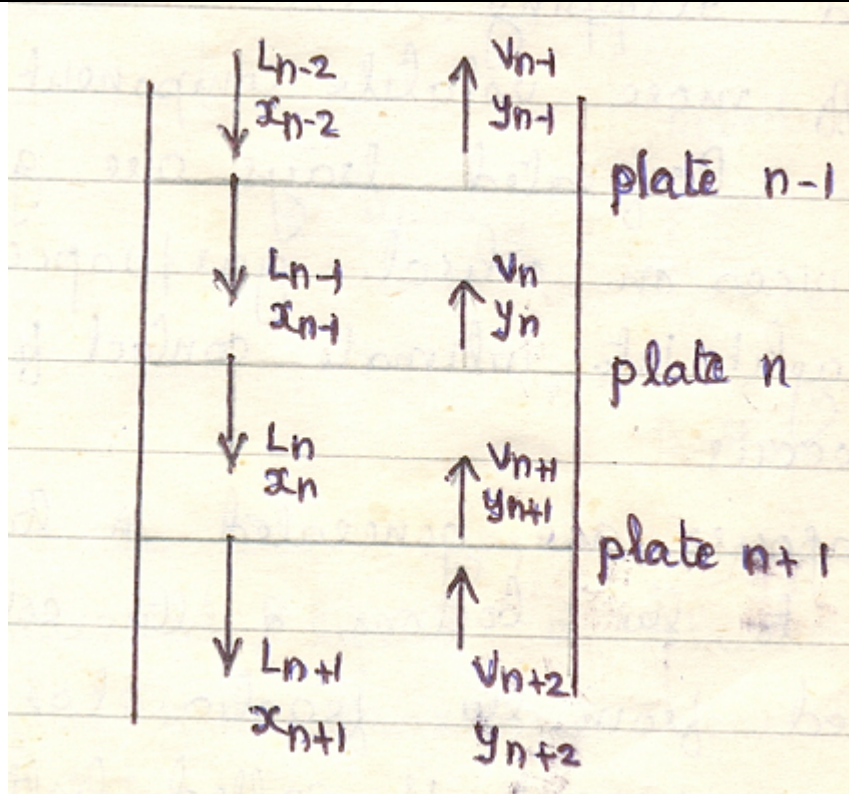
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The plates are numbered serially from top to bottom. On every plate two different fluid streams not at equilibrium are brought into intimate contact, mass transfer takes place, phases are separated, and finally two fluid streams leave the plate in equilibrium with each other.

When vapour from plate n+1 is brought into intimate contact on plate n with liquid from plate n-1, their composition change to attain equilibrium values. During the interchange process, some of more volatile component is vaporized from liquid L_{n-1} , decreasing the liquid concentration from x_{n-1} to x_n and some of the less volatile component is condensed from the vapour V_{n+1} , increasing the vapour concentration from y_{n+1} to y_n . In the column, the heat to vaporize more volatile component from liquid is supplied by the heat released in the condensation of less volatile component from vapour. The more volatile

2



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	component is transferred to the vapour rising up from the liquid running down the column , while the less volatile component is transferred to the liquid running down from the vapour rising up the column. The temperature decreases along the column height.		
5-c	<p>In <u>chemical processing</u>, a packed bed is a hollow <u>tube</u>, pipe, or other vessel that is filled with a packing material. The packing can be randomly filled with small objects like <u>Raschig rings</u> or else it can be a specifically designed <u>structured packing</u>. Packed beds may also contain catalyst particles or adsorbents such as zeolite pellets, granular activated carbon, etc.</p> <p>The purpose of a packed bed is typically to improve contact between two <u>phases</u> in a chemical or similar process. Packed beds can be used in a <u>chemical reactor</u>, a <u>distillation</u> process, or a <u>scrubber</u>, but packed beds have also been used to store <u>heat</u> in chemical plants. In this case, hot gases are allowed to escape through a vessel that is packed with a <u>refractory</u> material until the packing is hot. Air or other cool gas is then fed back to the plant through the hot bed, thereby pre-heating the air or gas feed.</p> <p>In industry, a packed column is a type of packed bed used to perform <u>separation processes</u>, such as <u>absorption</u>, <u>stripping</u>, and <u>distillation</u>. A packed column is a <u>pressure vessel</u> that has a packed section.</p>	4	4
5-d	<p>Feed line</p> <p>$q = 0$ (saturated vapour) $q = 1$ (saturated liquid) $0 < q < 1$ (mix of liquid and vapour) $q > 1$ (subcooled liquid) $q < 0$ (superheated vapour)</p>	4	4



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5-e	<p>Advantage and disadvantage of a packed column</p> <p>Advantages:</p> <ul style="list-style-type: none"> • Most cost-efficient distillation column when the diameter of the column is less than 0.6 m. • Because packing can be made from inert materials, packed beds are able to handle corrosive materials. • Lower pressure drop than in plate columns preventing column flooding. <p>Disadvantages:</p> <ul style="list-style-type: none"> • Packing can break during installation, or due to thermal expansion. • Not cost efficient for high liquid flow rates. • Contact efficiencies are decreased when the liquid flow rate is too low. 	<p>1 mark each for any 2</p> <p>1 mark each for any 2</p>	4
6-a	<p>X1= Initial moisture content, x= wt. Fraction of moisture in solid. =0.67/(1-0.67)=2.03</p> <p>X2= final moisture content= 0.25/(1-0.25)=0.333</p> <p>X*= Equilibrium moisture content = 0.01/(1-0.01)=0.0101</p>	<p>1</p> <p>1</p> <p>1</p>	8



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	$X_c = 0.40 / (1 - 0.40) = 0.67$ $R_c = 1.5 \text{ kg/m}^2 \cdot \text{h}$ $A/W' = 0.5$ $W'/A = 2.0$ $T = W' / (A \cdot R_c) [(X_1 - X_c) + (X_c - X^*) \ln ((X_c - X^*) / (X_2 - X^*))]$ $= 2 / 1.5 [(2.03 - 0.67) + (0.67 - 0.0101) \ln ((0.67 - 0.0101) / (0.333 - 0.0101))]$ $T = 2.44 \text{ h.}$	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p>	
6-b	<p>Rotary drum Dryer:</p> <p>Construction: It consists of a drum rotating in a tub of liquid to be filtered. The technique is well suited to slurries, and liquids with a high solid content, which could clog other forms of filter. The drum is pre-coated with a filter aid, typically of diatomaceous earth (DE) or Perlite. After pre-coat has been applied, the liquid to be filtered is sent to the tub below the drum. The drum rotates through the liquid and the vacuum sucks liquid and solids onto the drum pre-coat surface, the liquid portion is "sucked" by the vacuum through the filter media to the internal portion of the drum, and the filtrate pumped away. The solids adhere to the outside of the drum, which then passes a knife, cutting off the solids and a small portion of the filter media to reveal a fresh media surface that will enter the liquid as the drum rotates. The knife advances automatically as the surface is removed.</p> <p>A rotary vacuum filter consists of a large rotating drum covered by a cloth. The drum is suspended on an axial over a trough containing liquid/solids slurry with approximately 50-80% of the screen area immersed in the slurry.</p> <p>Working: As the drum rotates into and out of the trough, the slurry is sucked</p>	<p>3</p> <p>2</p>	8

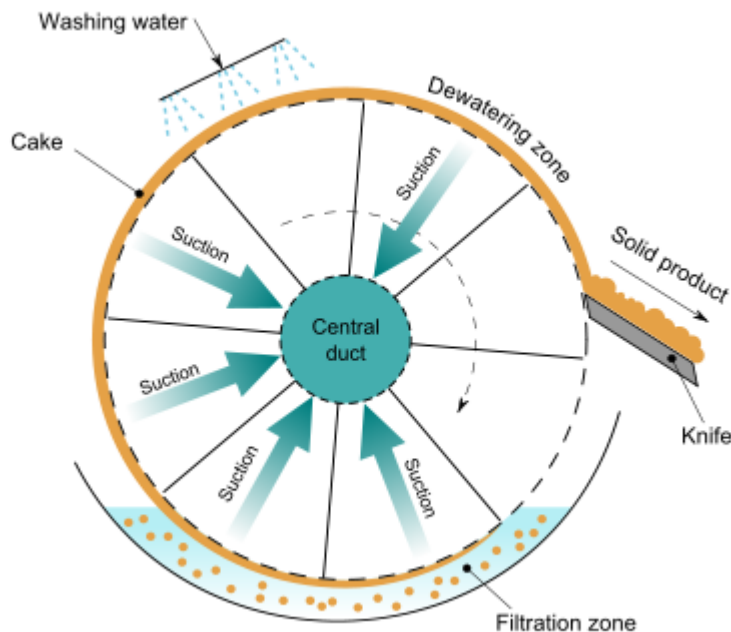


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on the surface of the cloth and rotated out of the liquid/solids suspension as a cake. When the cake is rotating out, it is dewatered in the dewatering zone. The cake is dry because the vacuum drum is continuously sucking the cake and taking the water out of it. At the final step of the separation, the cake is discharged as solids products and the drum rotates continuously to another separation cycle.



3

6-c

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 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 maximum conc of solution which can be achieved by bringing solid-solute into eqm with liquid

5

8

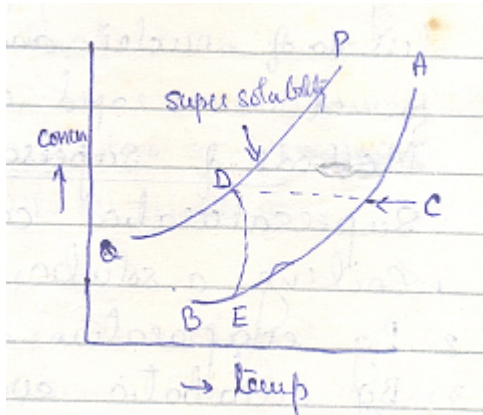


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solvent. If a solution having the composition and temp indicated by point C is cooled in the direction shown by the arrow it first crosses the solubility curve AB and it is expected to start of crystallization. Actually if the process started with 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.



3