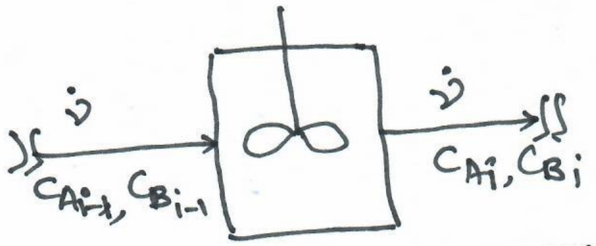
Quiz-11

19-Mar-2019 [F.M.-10]



[2 Marks]

Mole in − Mole out + generation − consumption = accumulation

$$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$$
(A) (B)

a) At steady state accumulation = 0

Apply mole balance on component A.

generation = 0

Mole in = $\dot{\nu} C_{Ai-1}$, Mole out = $\dot{\nu} C_{Ai}$, consumption = $K C_{Ai} C_{Bi} V = r.V$

So,
$$\dot{\nu} C_{Ai-1} - \dot{\nu} C_{Ai} - K V C_{Ai} C_{Bi} = 0$$

$$\Rightarrow C_{Ai-1} = C_{Ai} + K \frac{V}{\dot{\nu}} C_{Ai} C_{Bi}$$

$$\Rightarrow C_{Ai-1} = C_{Ai} + K\tau C_{Ai} C_{Bi} \quad [\tau = \frac{V}{\dot{\nu}}] \text{ — (1)}$$ [2 Marks]

(b) Similarly by applying mole balance on component B

$$\Rightarrow C_{Bi-1} = C_{Bi} + K\tau C_{Ai} C_{Bi} \text{ — (2)}$$

From equation (1) & (2) we get

$$C_{Ai-1} - C_{Bi-1} = C_{Ai} - C_{Bi}$$

If we do the balance on $i-1$ th ~~tank~~ CSTR we get

$$C_{Ai-2} - C_{Bi-2} = C_{Ai-1} - C_{Bi-1}$$

From the first ~~tank~~ CSTR

$$C_{A0} - C_{B0} = C_{A1} - C_{B1}$$

So, we can write.

$$C_{A0} - C_{B0} = C_{Ai} - C_{Bi}$$

$$\Rightarrow C_{Bi} - C_{Ai} = C_{B0} - C_{A0}, \text{ for all } i \text{ — (3)}$$ [2 Marks]

(b) From equation (3)

$$C_{Bi} = C_{Ai} + C_{B0} - C_{A0} \quad \text{— (4)}$$

From equation (4) & (1) we get

[2 Marks]

$$C_{Ai-1} = C_{Ai} + K\tau C_{Ai}(C_{Ai} + C_{B0} - C_{A0})$$

$$\Rightarrow K\tau C_{Ai}^2 + (K\tau(C_{B0} - C_{A0}) + 1) C_{Ai} - C_{Ai-1} = 0$$

$$\alpha C_{Ai}^2 + \beta C_{Ai} + \gamma = 0$$

So, $\alpha = K\tau$; $\beta = K\tau(C_{B0} - C_{A0}) + 1$ $\gamma = -C_{Ai-1}$

$$\therefore C_{Ai} = \frac{-\beta \pm \sqrt{\beta^2 - 4\alpha.\gamma}}{2\alpha}$$

$$= \frac{-K\tau(C_{B0} - C_{A0}) + 1 \pm \sqrt{(K\tau(C_{B0} - C_{A0}) + 1)^2 + 4K\tau C_{Ai-1}}}{K\tau}$$

$C_{Ai} > 0$

So,

$$C_{Ai} = \frac{-K\tau(C_{B0} - C_{A0}) + 1 + \sqrt{(K\tau(C_{B0} - C_{A0}) + 1)^2 + 4K\tau C_{Ai}}}{K\tau.}$$

[2 Marks]

Solution for Quiz-12

Due Date - 25-03-2019

Max Marks - 10

Sol^n:

For benzene toluene mixture at 80°C.

For benzene:

$$\log P_B^v = A - \frac{B}{T+C}$$

$$\Rightarrow \log P_B^v = 6.906 - \frac{1211}{80+220.8}$$

$$\Rightarrow P_B^v = 10^{2.88} = 758.698 \text{ mm Hg} = 0.998 \text{ atm} \quad \text{—— } 1$$

For toluene:

$$\log P_t^v = A - \frac{B}{T+C}$$

$$= 6.9533 - \frac{1343.9}{80+219.35}$$

$$\Rightarrow P_t^v = 291 \text{ mm Hg} = 0.3829 \text{ atm} \quad \text{—— } 1$$

For $x_B = 0.5$, $x_T = 0.5$

$P_B = 0.5 \times 0.998 = 0.4991$

$P_t = 0.5 \times 0.3829 = 0.1914$

$\therefore P_{total} = 0.6905$ atm —— 2

Also, $y_B = \frac{P_B}{P_{total}} = 0.722$

$y_t = \frac{P_t}{P_{total}} = 0.277$ —— 1

Calculations for other mole fractions:

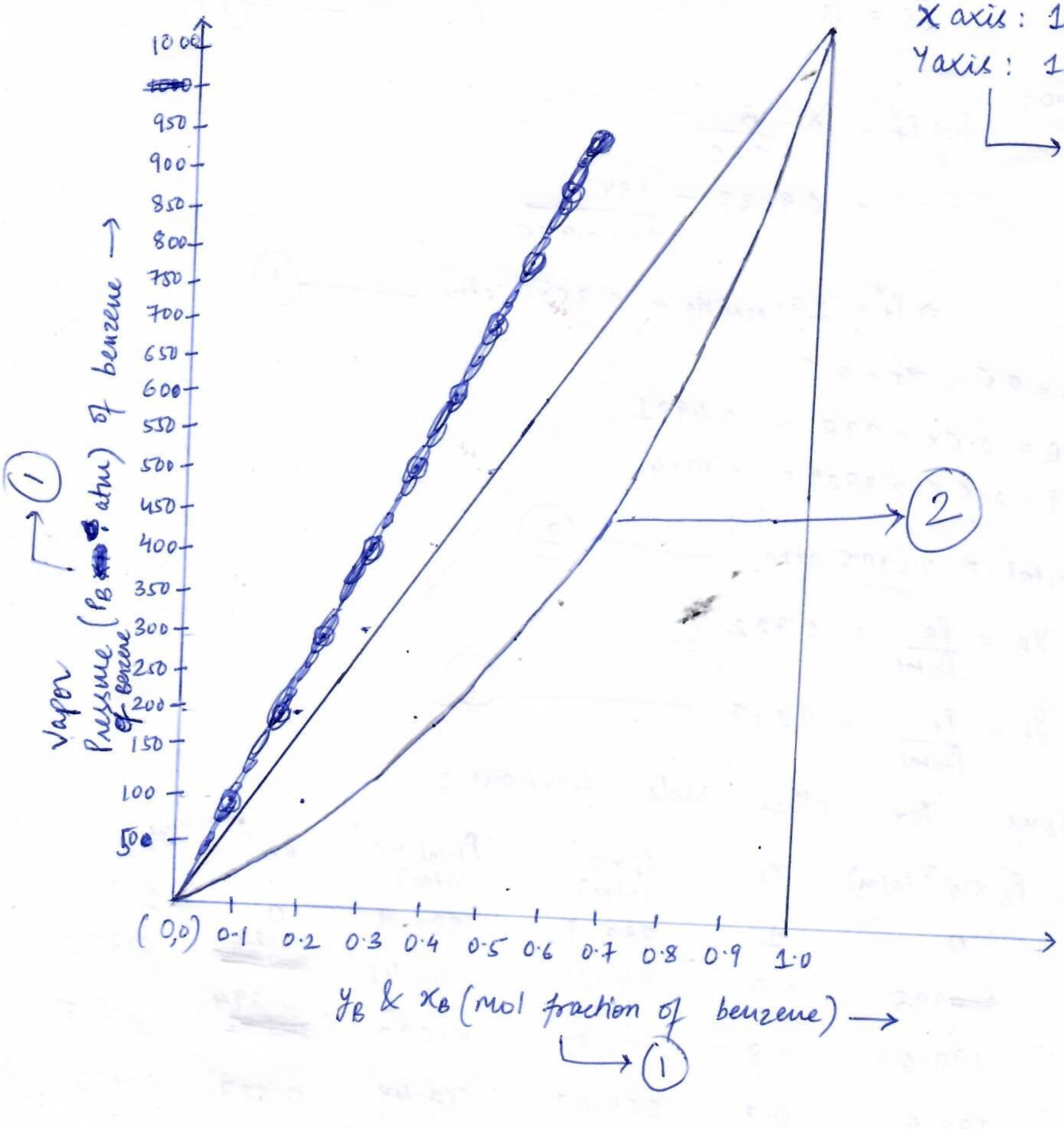
x_B	$P_B \times 10^{-3}$ (atm)	x_t	$P_t \times 10^{-3}$ (atm)	$P_{total} \times 10^{-3}$ (atm)	y_B	y_t
0	0	1	382.9	382.9	0	1
0.1	99.8	0.9	344.61	444.41	~~[illegible]~~ 0.224	0.775
0.2	199.6	0.8	306.32	505.92	~~0.651~~ 0.394	0.605
0.3	299.4	0.7	268.03	567.43	0.527	0.472

0.4	399.2	0.6	229.74	628.94	0.634	0.365
0.5	499	0.5	191.45	690.45	0.722	0.277
0.6	598.8	0.4	153.16	751.96	0.796	0.203
0.7	698.6	0.3	114.87	813.47	0.858	0.141
0.8	798.4	0.2	76.58	874.98	0.912	0.087
0.9	898.2	0.1	38.29	936.49	0.959	0.04
1.0	998	0	0	998	1	0

→ 3

Pxy diagram : Graph - 5 marks

Scale:
X axis : 1cm = 0.1 un
Y axis : 1cm = 50 $\times 10^{-3}$
→ 1



Quiz-13 Full Marks-15

13.1. Basis: 1 hr.

Assume ideal gas

$PV = nRT$ $V = 200\ m^3 = 200 \times 1000\ L$; $T = 273\ K$

$P = 1$ atm.

$$\Rightarrow n = \frac{PV}{RT} = \frac{1 \times 200 \times 10^3}{0.0821 \times 273.15} = 8918.3 \approx 8919 \text{ mol.}$$ — [1]

From Antoine equation

$\log_{10} P^*_{90} = A - \frac{B}{T+C}$ [90°C] — [1]

$$\Rightarrow \log_{10} P^*_{90} = 8.07131 - \frac{1730.63}{233.426 + 90}$$

$\Rightarrow P^*_{90} = 525.266$ ~~atm~~ mm Hg

$= 0.69$ atm

at 0°C.

$$\log_{10} P^*_0 = 8.07131 - \frac{1730.63}{233.426}$$ — [1]

$P^*_0 = 4.542$ mm Hg. $= 5.9 \times 10^{-3}$ atm

At input.

50% relative humidity. ∴ so, partial pressure of water $= \frac{P^*_{90}}{2}$

so, $\frac{P_{90}}{2} = y_{H_2O} \times P$

$$\Rightarrow y_{H_2O} = \frac{P^*_{90}}{2 \times P} = \frac{0.69}{2 \times 10} = 0.0345$$

∴ n_{wa} at input $= 0.0345 \times 8919$ mol $= 307.7 \approx 308$ mol — [1]

Assumption: (1) ~~stre~~ steam is saturated after cooling

(2) No air loss.

at 0°c (output)

P_w = Partial pressure of water = $P_0^* = 5.9 \times 10^{-3}$ atm

$P_{air} = P_{total} - P_w = 1 - 5.9 \times 10^{-3} = 0.9941$ atm.

$P_{air} \cdot V_{total} = n_{air} RT$

$\Rightarrow V_{total} = \frac{8611 \times 0.0821 \times 273.15}{0.9941}$

$= 194253$ l. __[1]

$n_{air} = n_{total} - n_w$

$= 8919 - 308$ mol

$= 8611$ mol __[1]

$P_w \cdot V_{total} = n_w RT$ [in condensed steam]

$\Rightarrow n_w = \frac{5.9 \times 10^{-3} \times 194253}{0.0821 \times 273.15} = 51.1$ mol ≈ 52 mol. __[1]

$308 - 52 = 256$ mol ~~conde~~ of water condensed.

256 mol/hr will condense. __ [1]

13.2. Input steam.

Molal humidity $= \frac{P_w \times 100\%}{P_{total} - P_w} = 3.57\%$. [1]

Absolute humidity $= \frac{P_w M_w}{(P_{air}) M_{air}} \times 100\%$ [1]

$M_w = 18.02$

$M_{air} = 28.97$

$= 2.22\%$

Percentage humidity $= \frac{P_w / (P_{total} - P_w)}{(P_w^* / (P_{total} - P_w^*))} \times 100\%$. [1]

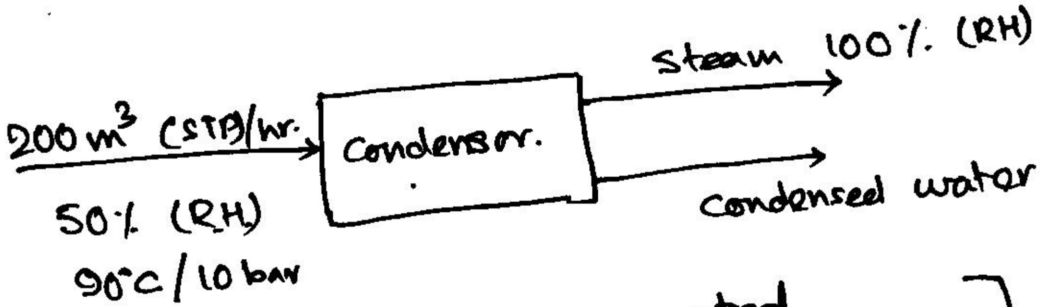
$= 48.17\%$.

Output Steam.

Molal humidity = ~~[illegible]~~ 0.594 % [1]

Absolute humidity = ~~[illegible]~~ 0.369 % [1]

Percentage humidity = 100 % [1]



[1]

[Other methods are also accepted.
For calculation error 2 marks deducted.
For conceptual error 3/4 marks deducted.]