Q.P 27313 (1)

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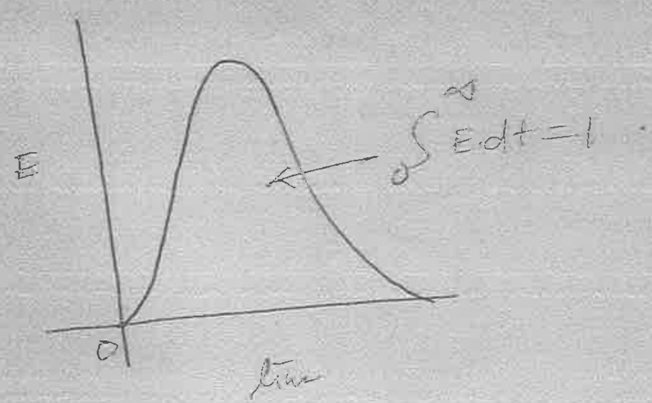
Q. 2 (b) $\bar{t} = \dfrac{\sum t_i C_i \Delta t_i}{\sum C_i \Delta t_i}$, $\Delta t = 5$ min

$\therefore \bar{t} = 15$ min.

Area. $\sum C_i \Delta t_i = 100$ gm. min/lit

$$E = \frac{C}{\int_0^\infty C\,dt}$$



Q. 3. (a) $\rho_B = \dfrac{2.4}{12} = 0.2$ mol/cc.

$P_{As} = X_A \cdot P = \dfrac{12}{100} \times 1 = 0.12$ atm

$C_{Ag} = \dfrac{P_{Ag}}{RT} = \dfrac{0.12}{82.06 \times 1173} = 1.25 \times 10^{-6}$ mol/cc

$\therefore \tau = \dfrac{\rho_B \cdot R}{b \cdot K'' C_{As}} = \dfrac{0.2 \times 12}{1 \times 25 \times 1.25 \times 10^{-6}}$

$\boxed{\tau = 7680 \text{ sec}}$

PAGE. 3

Q.3.(b) (i) Chemical Rea.

$$1-\bar{X}_B = \frac{1}{4}\left(\frac{\tau}{\bar{t}}\right) - \frac{1}{20}\left(\frac{\tau}{\bar{t}}\right)^2 + \frac{1}{120}\left(\frac{\tau}{\bar{t}}\right)^3 - \cdots$$

$\tau = 20\text{min}$, $\bar{t} = 48$ min.

$$\boxed{1-\bar{X}_B = 0.096}$$

(ii) Ash Diffusion

$$1-\bar{X}_B = \frac{1}{5}\left(\frac{\tau}{\bar{t}}\right) - \frac{19}{420}\left(\frac{\tau}{\bar{t}}\right)^2 + \frac{41}{4620}\left(\frac{\tau}{\bar{t}}\right)^3 - \cdots$$

$$\boxed{1-\bar{X}_B = 0.076}$$

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Q.4.(b) $A \rightarrow 3R$, $\varepsilon_A = \frac{3-1}{1} = 2$

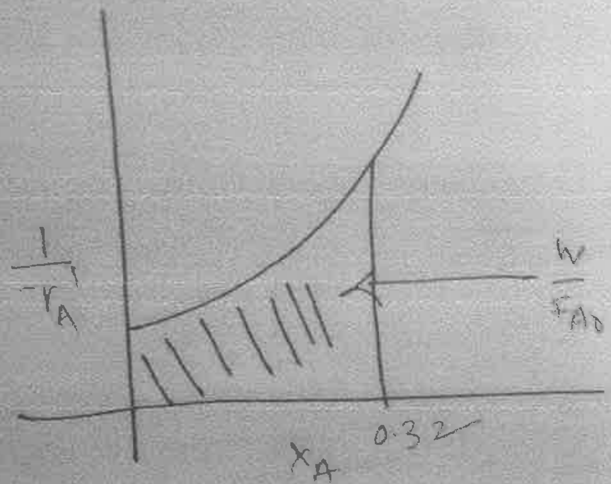
$$C_{A_0} = \frac{P_{A_0}}{RT} = \frac{3.5}{0.08206 \times 388} = 0.1099$$

$x_A = 0.32$, $F_{A_0} = 1500$ mol/hr.

$$\frac{W}{F_{A_0}} = \int_0^{x_A} \frac{dx_A}{-r_A'} = \int_0^{0.32} \frac{dx_A}{-r_A}$$

$$X_A = \frac{1 - C_A/C_{A_0}}{1 + \frac{\varepsilon_A C_A}{C_{A_0}}}$$

x_A	0.368	0.217	0.135	0.769
$\frac{1}{-r_A}$	0.2357	0.1754	0.1389	0.1136



$\frac{W}{F_{A_0}} = 0.04875$

$\boxed{W = 73.125 \text{ kg.}}$

Q.5. PAGE-5

Solution : A (g $\rightarrow$ l) + B(l) $\rightarrow$ R(l) , $k = \infty$

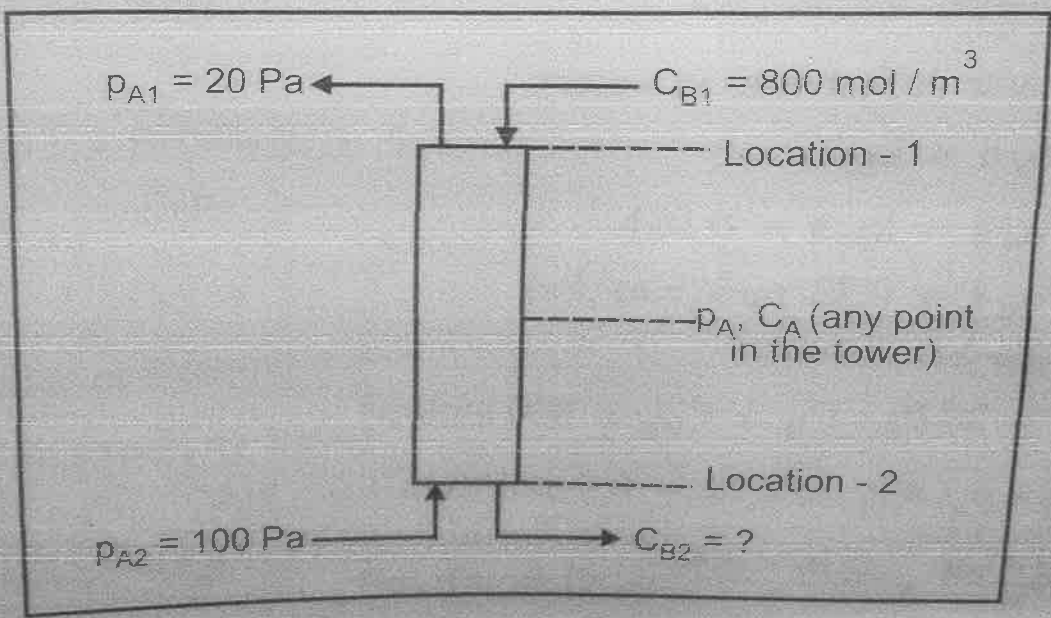
It is an extremely rapid reaction (an instantaneous reaction)

Here b = 1 (stoichiometric coefficient of B)

$$p_{A\,in} = p_{A2} = 100 \text{ Pa}$$

80% of A is removed from air

$$\therefore \quad p_{A\,out} = p_{A1} = 100\,(1 - 0.80) = 20 \text{ Pa}$$



Q. 5 PAGE-6

First find C_{B2} with the help of material balance.

C_{B2} is the concentration of B in the exit stream from the tower.

For dilute solutions, the simplified material balance yields

$$(p_A - p_{A1}) = \frac{(F_l/A_{cs})\,\pi}{(F_g/A_{cs})\,b\,C_T}(C_{B1} - C_B)$$

$p_{A1} = 20$ Pa, $\pi = 10^5$ Pa, $b = 1$, $C_T = 56000$ mol/m^3, $C_{B1} = 800$ mol/m^3

$$F_l/A_{cs} = 7 \times 10^5 \text{ mol/(h.m}^2)$$

$$F_g/A_{cs} = 1 \times 10^5 \text{ mol/(h.m}^2)$$

Substituting the above values, Equation (1) becomes

$$p_A - 20 = \frac{7 \times 10^5 \times 10^5}{1 \times 10^5 \times 1 \times 56000}(800 - C_B)$$

$$p_A = 10020 - 12.5\,C_B$$

or $$C_B = 801.6 - 0.08\,p_A$$

The above equation relates C_B to p_A at any point in the tower.

At the bottom of the tower :

$$p_A = p_{A2} = 100 \text{ Pa}$$

We have : $$C_{B2} = 801.6 - 0.08\,p_{A2}$$

$\therefore$ $$C_{B2} = 801.6 - 0.08 \times 100 = 793.6 \text{ mol/m}^3$$

It is given that the reaction is extremely rapid (instantaneous).

To find the appropriate form of the rate equation, we have to determine whether it i instantaneous reaction with low or high C_B and for this estimate $k_{Ag}\,a\,p_A$ and $k_{Bl}\,a\,C_B/b$ at ends of the tower.

As $\mathscr{D}_{Bl} = \mathscr{D}_{Al}$ (same diffusivities in water)

$$k_{Al}\,a = k_{Bl}\,a$$

We have $$k_{Al}\,a = k_{Bl}\,a = 0.10 \text{ h}^{-1}$$

$$k_{Ag}\,a = 0.32 \text{ mol/(h.m}^3\text{.Pa)}$$

At top of the tower :

$$p_A = p_{A1} = 20 \text{ Pa}, \quad C_B = C_{B1} = 800 \text{ mol/m}^3$$

$$k_{Ag}\,a\,p_A = 0.32 \times 20 = 6.4 \text{ mol/(h.m}^3)$$

$$\frac{k_{Bl}\,a\,C_B}{b} = \frac{0.10 \times 800}{1} = 80 \text{ mol/(h.m}^3)$$

$\therefore$ $$k_{Ag}\,a\,p_A < k_{Bl}\,aC_B/b$$

Q.5. PAGE-7

At bottom of the tower :

$$p_A = p_{A2} = 100 \text{ Pa}, \quad C_B = C_{B2} = 793.6 \text{ mol/m}^3$$

$$k_{Ag}\, a\, p_A = 0.32 \times 100 = 32 \text{ mol/(h.m}^3)$$

$$\frac{k_{Bl}\, a\, C_B}{b} = \frac{0.1 \times 793.16}{1} = 79.32 \text{ mol/(h.m}^3)$$

At both ends of tower, $k_{Ag}\, a\, p_A < k_{Bl}\, a\, C_B/b$

As $k_{Ag}\, a\, p_A < k_{Bl}\, a\, C_B/b$, we have :

Instantaneous reaction with high C_B. Gas phase resistance controls. **Reaction zone is at the** interface and so the form of rate equation is

$$-r_A''' = \left(-r_A''\right) a = k_{Ag}\, a\, p_A$$

$$-r_A''' = 0.32\, p_A$$

The height of tower is given by

$$h = \frac{(F_g/A_{cs})}{\pi} \int_{p_{A1}}^{p_{A2}} \frac{dp_A}{-r_A'''}$$

$$= \frac{(F_g/A_{cs})}{\pi\,(0.32)} \int_{20}^{100} \frac{dp_A}{p_A}$$

$$= \frac{1 \times 10^5}{1 \times 10^5 \times 0.32}\, ln\,(100/20)$$

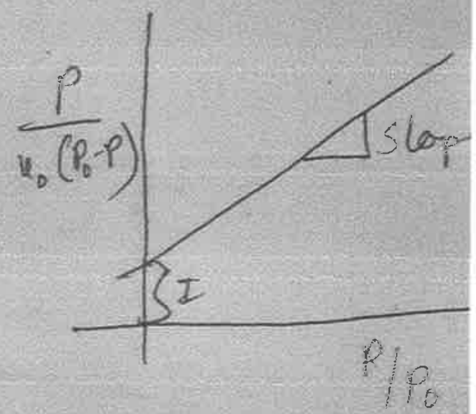
$$= 5.03 \text{ m}$$

Height of the tower for countercurrent operation $= 5.03$ m ... **Ans.**

Q.6 (b) PAGE 8

→ Given 8.01 gm cat-sample

$P_0 = 1\,\text{atm} = 760$ mm Hg.



$$\frac{P}{v(P_0-P)} = \frac{1}{v_m c} + \frac{(c-1)\,P}{c\,v_m P_0}$$

$$I = \frac{1}{v_m c} \quad , \qquad \text{slope} = \frac{c-1}{c\,v_m} = S$$

combine I & S ⇒.

$$c = \frac{1}{I v_m} \quad \Rightarrow \quad S = \frac{\frac{1}{I v_m} - 1}{\frac{1}{I v_m}\, v_m}.$$

$v_m =$ ______ ?.

$$\boxed{S_g = 4.35 \times 10^4\, v_m}$$

Marks Awarded

PAGE- 1

Q.2. a (i) For M.B. we have

$$\text{Area under curve} = \frac{M}{V} = \frac{1}{4} = 0.25 \text{ mol.min/lit}$$

(ii) From tracer curve, we have

$$\text{AUR of fig. a} = \text{Area of rectangle}$$
$$= 0.05 \times 5 = 0.25 \text{ mol.min/lit}.$$

— Ans (i)

$$\bar{t} = \frac{\Sigma t_i C_i}{\Sigma C_i} = 2.5 \text{ min}$$

From fig. $\bar{t} = \dfrac{\Sigma t_i C_i \Delta t_i}{\Sigma C_i \Delta t_i}$

Take $t = 0, 1, 2, 3, 4$ & 5

$\therefore \Delta t_i = 1$ min

$\therefore \bar{t} = 2.5$ min — Ans.

$$\bar{t} = \frac{V}{v_0} \Rightarrow V = \bar{t}\, v_0 = 2.5 \times 4 = 10 \text{ lit}$$

$$\therefore E = \frac{C_{pulse}}{M/v} = \frac{C}{0.25} = 4C.$$