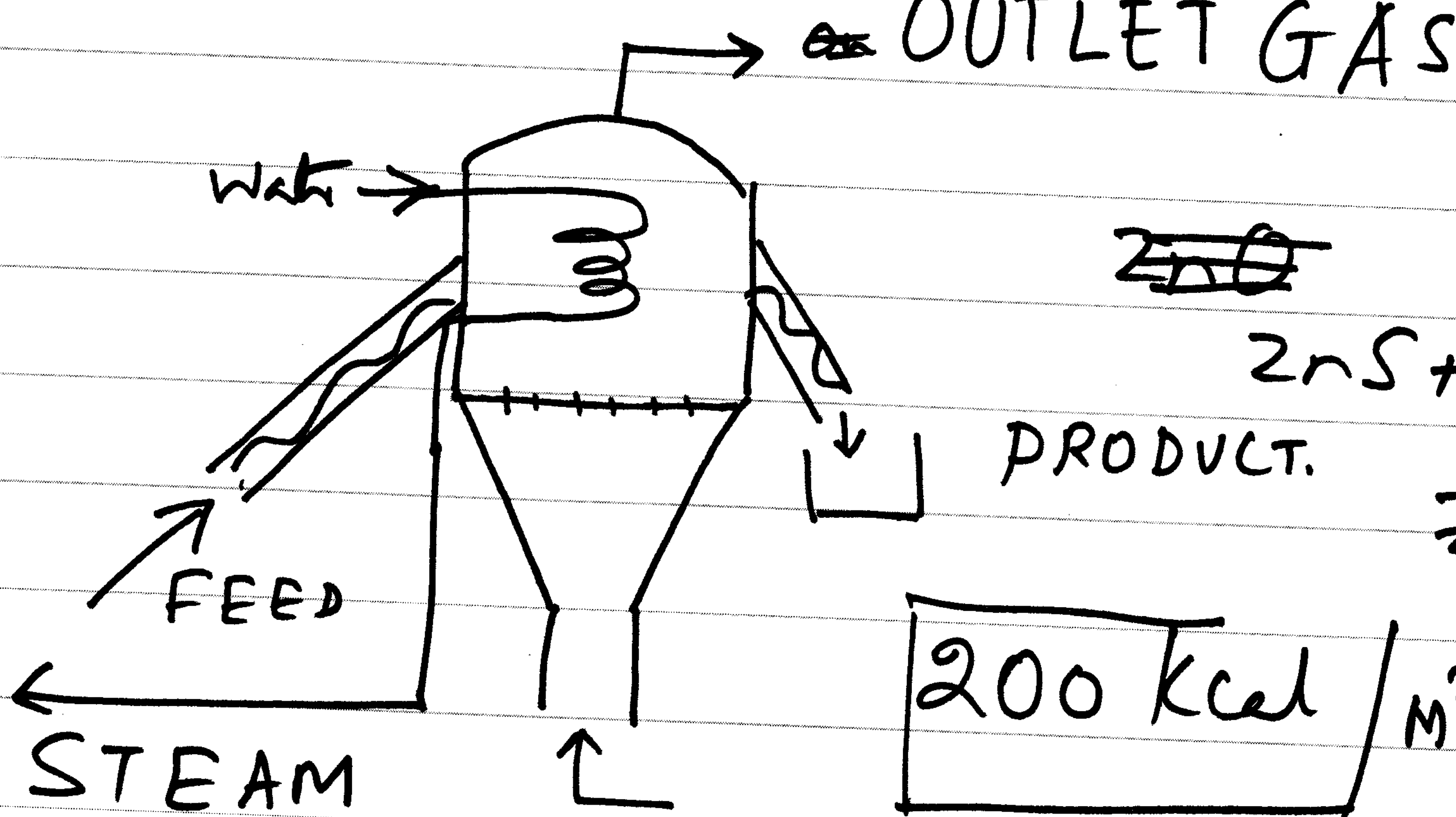
Prof. H. Shankar

NON Catalytic GAS SOLID RXNS

Practice Problems

FLUIDISED BED.



~~ZnO~~

$ZnS + O_2 \rightarrow ZnO + SO_2$

$\boxed{200 \text{ Kcal} / m^2 \, hr \, {}^\circ C}$

$S + O_2 = SO_2$

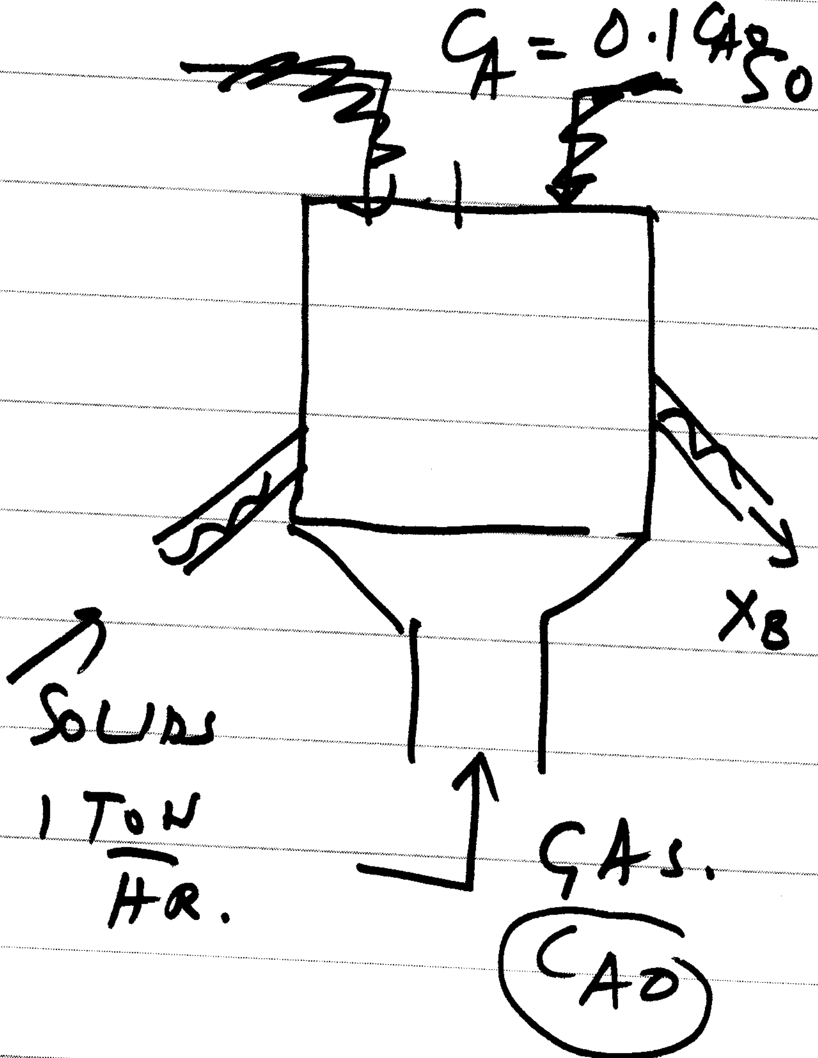
1000 tons / DAY SO_2

500 TONS / DAY S

2000 tons of STEAM

0.25MWH / ton of STEAM.

500MWH / DAY $\Rightarrow$ 20MW

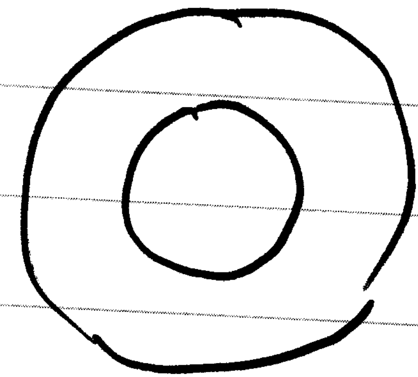


$X_A = 0.90$

$A(g) + B(s) \longrightarrow R(g) + S(s).$

RXN. CONTROL

1 HR.



RXN CONTROL.

$$\frac{d}{dt}(N_B) = (r_B S) = -(k_s C_{Ag}) 4\pi r_c^2$$

$$\frac{d}{dt}\left(\frac{4}{3}\pi r_c^3 \rho_B\right) = -k_s C_{Ag} 4\pi r_c^2$$

$$\left(1 - r_c/R\right) = t/\tau_R.$$

$$\tau_R = \frac{\rho_B R.}{k_s C_{A_g} b}$$

$$\tau_R (0.1\, C_{A0}) = 10 \text{ Hrs}$$

$$r_c/R = 1 - t/\tau_R.$$

$$\left(1 - X_B\right)^{1/3} = 1 - t/\tau_R.$$

$$\left(1 - X_B\right) = \left(1 - t/\tau_R\right)^3$$

$$\overline{(1-X_B)} = \int_0^{\infty} (1-X_B)\, \underline{\underline{E(t)}}\, dt.$$

$$\int_0^{\tau} (1-X_B)\, E(t)\, dt + \int_{\tau}^{\infty} (1-X_B)\, E(t)\, dt$$

$$\overline{(1-X_B)} = \int_0^{\tau} \left(1-t/\tau_R\right)^3 \frac{1}{\bar{t}}\, e^{-t/\bar{t}}\, dt$$

$$\overline{(1-X_B)} = \int_0^{\tau_R} \left[1 - 3\left(\frac{t}{\tau_R}\right) + 3\left(t/\tau_R\right)^2 - \left(\frac{t}{\tau_R}\right)^3 \right] \frac{1}{\bar{t}} e^{-t/\bar{t}}\, dt.$$

$$\bar{X}_B = \frac{3}{\alpha} - \frac{6}{\alpha^2} + \frac{6}{\alpha^3} - \frac{6e^{-\alpha}}{\alpha^3}$$

$$\alpha = \tau_R / \bar{t}$$

$$0.9 = \frac{3}{\alpha} - \frac{6}{\alpha^2} + \frac{6}{\alpha^3} - \frac{6e^{-\alpha}}{\alpha^3}$$

$\alpha = 10$

$$RHS = \frac{3}{10} - \frac{6}{100} + \frac{6}{1000} - \frac{6e^{-10}}{1000}$$

$$= 0.24$$

$\alpha = 5$:

$$\frac{3}{5} - \frac{6}{25} + \frac{6}{125} - \frac{6e^{-5}}{125}$$

$$RHS = 0.41$$

$\alpha = 1$:

$$RHS \quad \frac{3}{1} - \frac{6}{1} + \frac{6}{1} - \frac{6e^{-1}}{1}$$

$RHS = 0.79$

$\alpha = 0.5$: $\dfrac{3}{0.5} - \dfrac{6}{0.25} + \dfrac{6}{0.125} - \dfrac{6e^{-0.5}}{0.125}$

$$\left.\begin{aligned} RHS &= 0.89 \\ LHS &= 0.9 \end{aligned}\right\}$$

$\alpha = 0.4 \quad x_B = 0.9$

$\alpha = 0.4$

$$\frac{W}{F_s} = \bar{t}$$

$\alpha = \tau / \bar{t}$

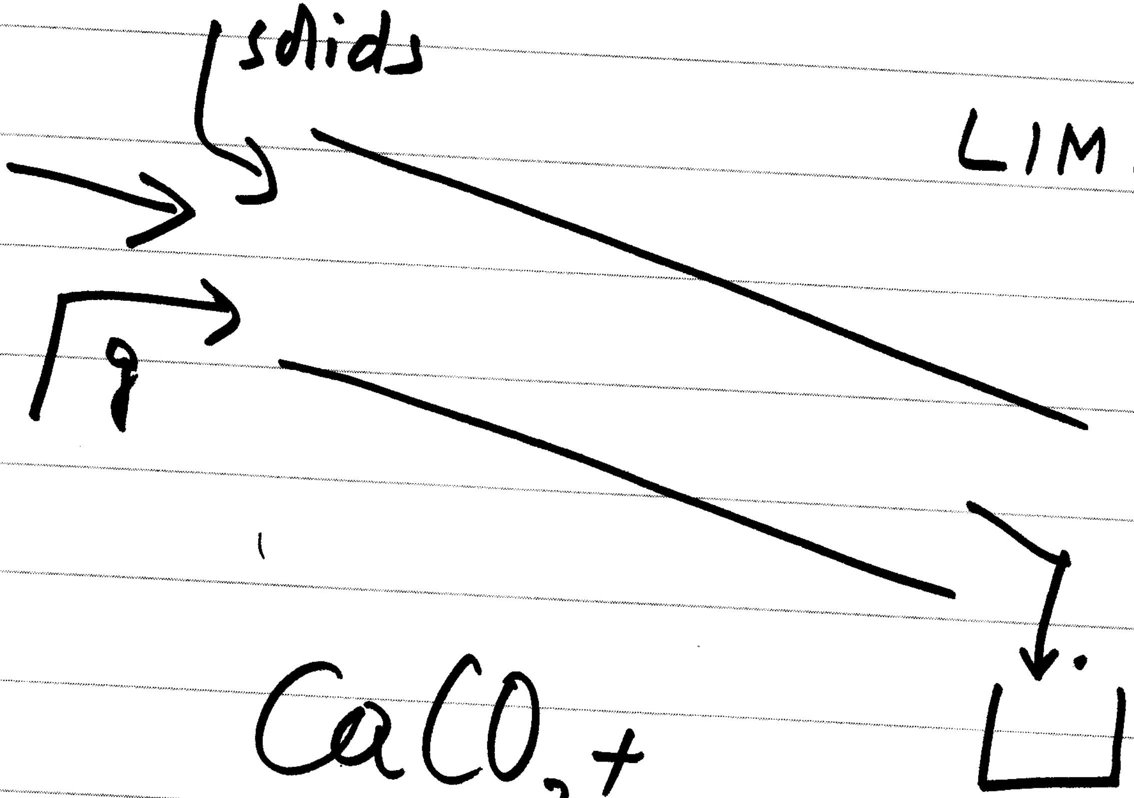
$0.4 = 10 / \bar{t}$

$\bar{t} = 10/0.4 = 25 \text{ Hrs}.$

$\frac{W}{1} = 25$ $\qquad$ $\underline{\underline{W = 25 \text{ tons}}}$

$$\boxed{\ln \frac{\beta - x_A}{\beta} = -\tau_g \alpha.}$$

LIME CALCINATION.



$$CaCO_3 + \quad \longrightarrow CaO + CO_2$$

$$\rightarrow A(g) + B(s) = C(g) + D(s)$$

ext Diffn Cuts

$$F_A = F_{A0}(1 - X_A)$$

$$F_B = F_{B0} - F_{A0} X_A$$

$$F_C = F_{C0} + F_{A0} X_A$$

$$F_D = F_{D0} + F_{A0} X_A$$

$$K_p = \left(P_C / P_A \right)^*$$

$$K_p = \frac{p_C^*}{p_A^*} = \left[\frac{C_{C0} + C_{A0} X_A}{C_{A0}(1 - X_A)}\right]^*$$

$$X_A^* = \left(\frac{K_p - \theta_C}{1 + K_p}\right)$$

$$\frac{dF_A}{dV} = r'_A (a_s) = k_g (C_A - C_A^*) a_s$$

$$-F_{A0}\frac{dx_A}{dV} = -k_g\left(C_A(1-x_A) - C_A(1-x_A^*)\right]a_s$$

$$\frac{dx_A}{d\tau_g} = k_g\left[x_A^* - x_A\right]a_s$$

$$a_S = \left(4\pi R^2\right) N / V$$

$$\epsilon_R = \frac{4}{3}\pi R^3 N / V$$

$$a_S = 3\epsilon_R / R.$$

$$\frac{dx_A}{d\tau_g} = \underbrace{\left(\frac{3\epsilon_R\, k_g}{R}\right)}_{\alpha.} \left[\underbrace{x_A^*}_{\beta.} - x_A\right].$$

$$\ln\left[\frac{\beta - x_A}{\beta}\right] = -\,\tau_g\,\alpha.$$

$$\alpha = \frac{3\,\epsilon_R\,h_g}{R}. = \frac{3(0.15)(0.01)}{0.05} \quad 0.09/s$$

$$\beta = \left(\frac{K_p - \theta_c}{1 + K_p}\right) = \frac{5 - 1}{6} = \frac{4}{6} = 0.67$$

$$x_e = 0.67$$

$$x_A = (0.67)\,0.8 = 0.536$$

$$\ln\left[\frac{0.67 - 0.536}{0.67}\right] = -\tau_g\,(0.09)$$

$$\underline{\underline{\tau_g = 17.8\ s.}}$$

~~GASLEI~~.

$$\tau_s = (V \epsilon_R) / (F_{B0} / \rho_B).$$

$$(V \epsilon_R) / (3.6 \times 0.7 / 50).$$

$$\tau_s = V (0.15) / (3.6 \times 0.7 / 50) = 2.67\,s$$

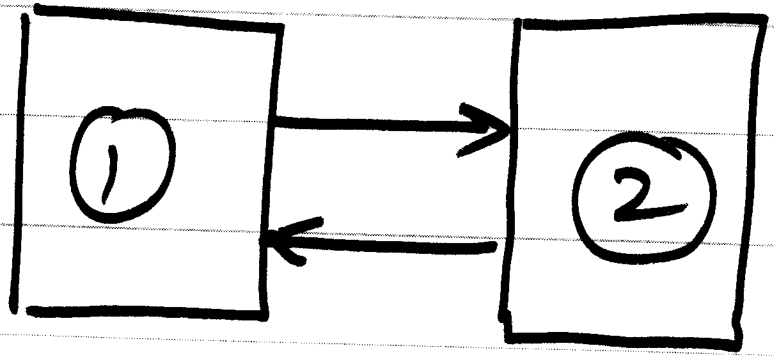
$$V = v_0 \tau_q = \left(\frac{3.6}{0.02}\right)\left(\frac{17.8}{3600}\right) = 0.89\,m^3$$

Q3.

$$C + H_2O = CO + H_2$$

Endothermic 25 kcal/mol.

$$C + H_2O = CO + H_2$$ | Coal Gasification



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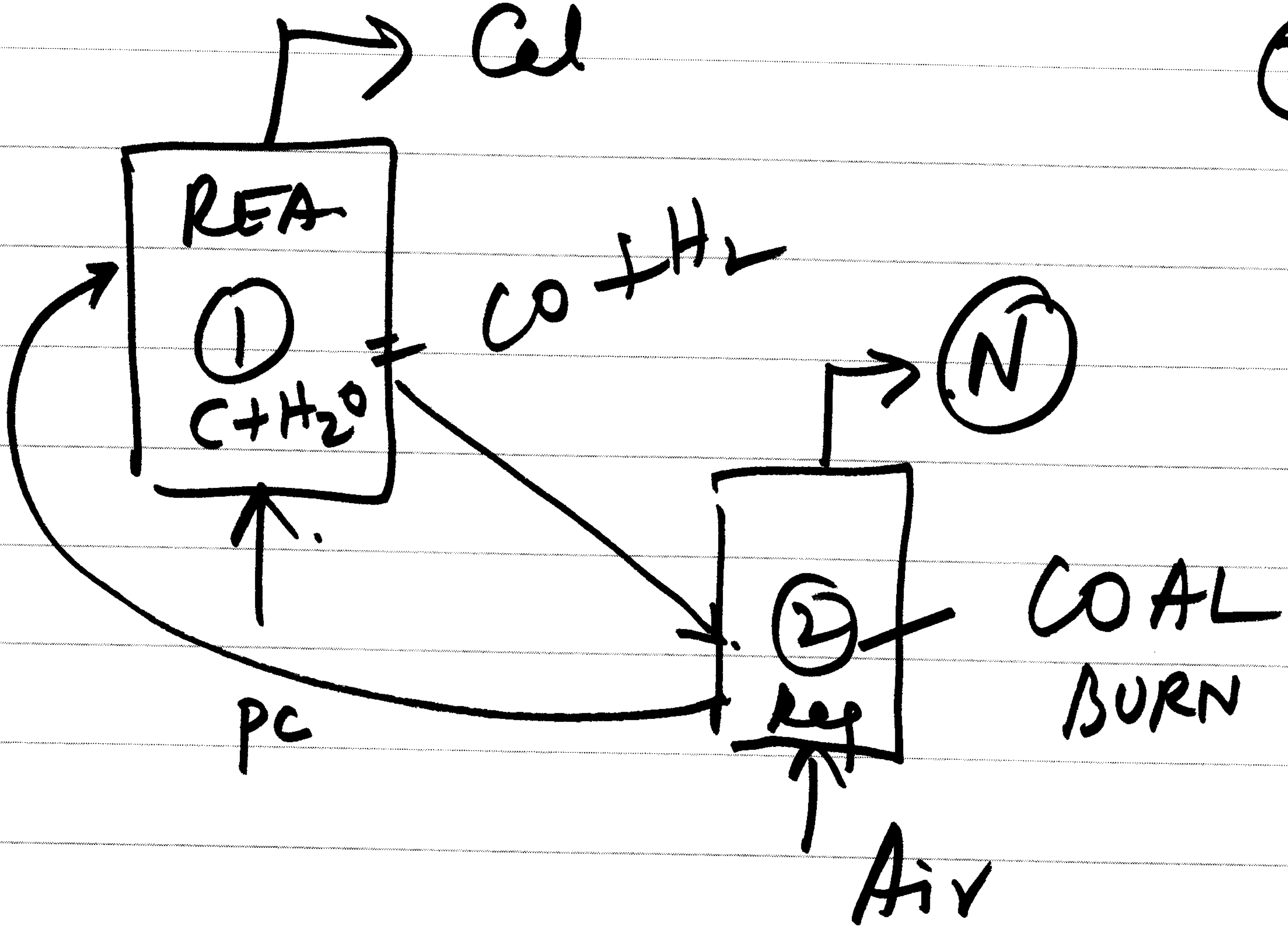


$$\cancel{4\pi r_c^2}\, \rho_0 \frac{dr_c}{dt} = -b k_s C_{Ag} \cancel{4\pi r_c^2} \quad (23)$$

$$\left(1 - \frac{r_c}{R}\right) = t / \tau_{RS}$$

$$\tau_{RS} = \frac{\rho_B R}{b k_s C_{Ag}}$$

$$\frac{d}{dt}\left(\frac{4}{3}\pi r_c^3 \rho_s\right) = -b\, k_g C_{Af}\, 4\pi r_c^2$$

$$Sh = \left(\frac{k_g R}{D}\right) = 2 + \cancel{\underline{(Re)(\text{const})}}$$

$$\frac{k_g r_c}{D} = 2$$

$$\frac{d}{dt}\left(\frac{4}{3}\pi r_c^3 \rho_B\right) = -b\,\frac{2D}{r_c}\,4\pi r_c^2 C_{Ag}$$

$$\cancel{4\pi} r_c^{\cancel{2}} \rho_B \frac{dr_c}{dt} = -b\,2D\,\cancel{4\pi r_c}\,C_{Ag}$$

$$r_c \rho_B \frac{dr_c}{dt} = -2Db\,C_{Ag}$$

$$r_c \frac{dr_c}{dt} = -\frac{2 D b C_{Ag}}{\rho_B} dt.$$

$$\left[\frac{r_c^2}{2}\right]_R^{r_c} = -\frac{2 D b C_{Ag}\, t}{\rho_B}$$

$$\left[\frac{R^2 - r_c^2}{2}\right] = \frac{2 D b C_{Ag}\, t}{\rho_B}$$

$$R^2\left[1 - \frac{r_c^2}{R^2}\right] = \frac{4 b D C_{Ag}\, t}{\rho_B}$$

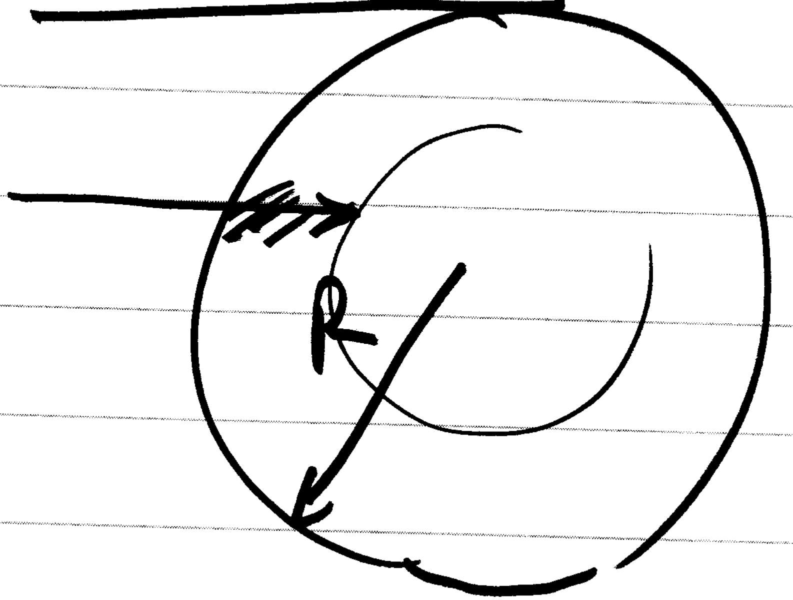
$$1 - \frac{r_c^2}{R^2} = \frac{4 b D C_{Ag} t}{\rho_B R^2}$$

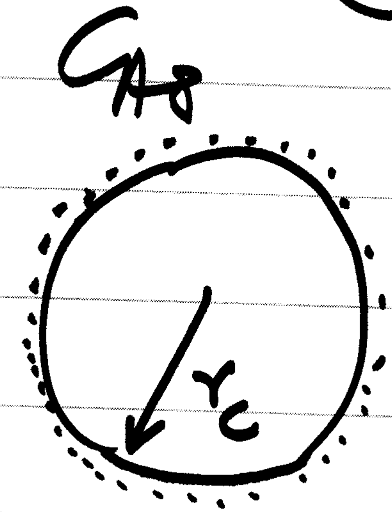
$$\tau = \rho_B R^2 / 4 b D C_{Ag}$$

$$\boxed{1 - \frac{r_c^2}{R^2} = t/\tau_{RES}}$$

$$1 - (1 - X_B)^{2/3} = t/\tau_{RES}$$

RXN CONTROL





$$\frac{dN_B}{dt} = \left(r_B' S\right)$$

$$\frac{d}{dt}\left(\frac{4}{3}\pi r_c^3 \rho_B\right) = -b\left(k_s\right) C_{Ag} 4\pi r_c^2$$

$$r_B \, \xi = -k_g (C_{Ag} - C_A^{*})$$

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$$F_A = F_{A0}(1 - X_A)$$

(1) $B = F_{B0} - F_{A0} X$

(2) $F_C = F_{C0} + F_{A0} X$

(2) $F_D = F_{D0} + F_{A0} X$

gas $F_t = F_{A0}(1 - X_A) + \cancel{F_{C0}} + F_{A0} X + F_{A0} X$

$$F_{A0}(1 + X_A)$$

$$K_p = \cancel{\frac{C_{A0}^2 X_A^2}{(1+X_A)^2 C_{A0}(1-X_A)}}$$

$$\cancel{K_p = X_A}$$

$$K_p = \frac{C_{A0} X_A}{(1+X_A)} \frac{C_{A0} X_A (1+X_A)}{(1+X_A) C_{A0} (1-X_A) RT}$$

$$K_p = \left[\frac{C_{A0} X_A^2}{RT(1-X_A^2)}\right]^*$$

$$A(g) + B(s) = C(g) + D(g)$$

H_2O

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$$K_p = \left(\frac{P_C \, P_D}{P_A}\right)^{*}$$

$$C_A = \frac{F_{A0}(1 - x_A)}{v_0(1 + x_A)} = C_{A0}\frac{(1 - x_A)}{1 + x_A}$$

$$C_C = \frac{\cancel{F_{C0}} + F_{A0} x_A}{v_0(1 + x_A)} = \frac{C_{A0} \, x_A}{(1 + x_A)}$$

$$C_D = \frac{C_{A0} \, x_A}{(1 + x_A)}$$

$$\cancel{\left(\frac{K_p}{C_{A0}}\right)}$$

$$\left(\frac{K_p RT}{C_{A0}}\right) = \left[\frac{X_A^2}{(1-X_A^2)}\right]^*$$

Solve. $X_A^* = f(\alpha)$