ENZYME PROBLEM 3B

"FIRST ORDER" $A \rightarrow B$

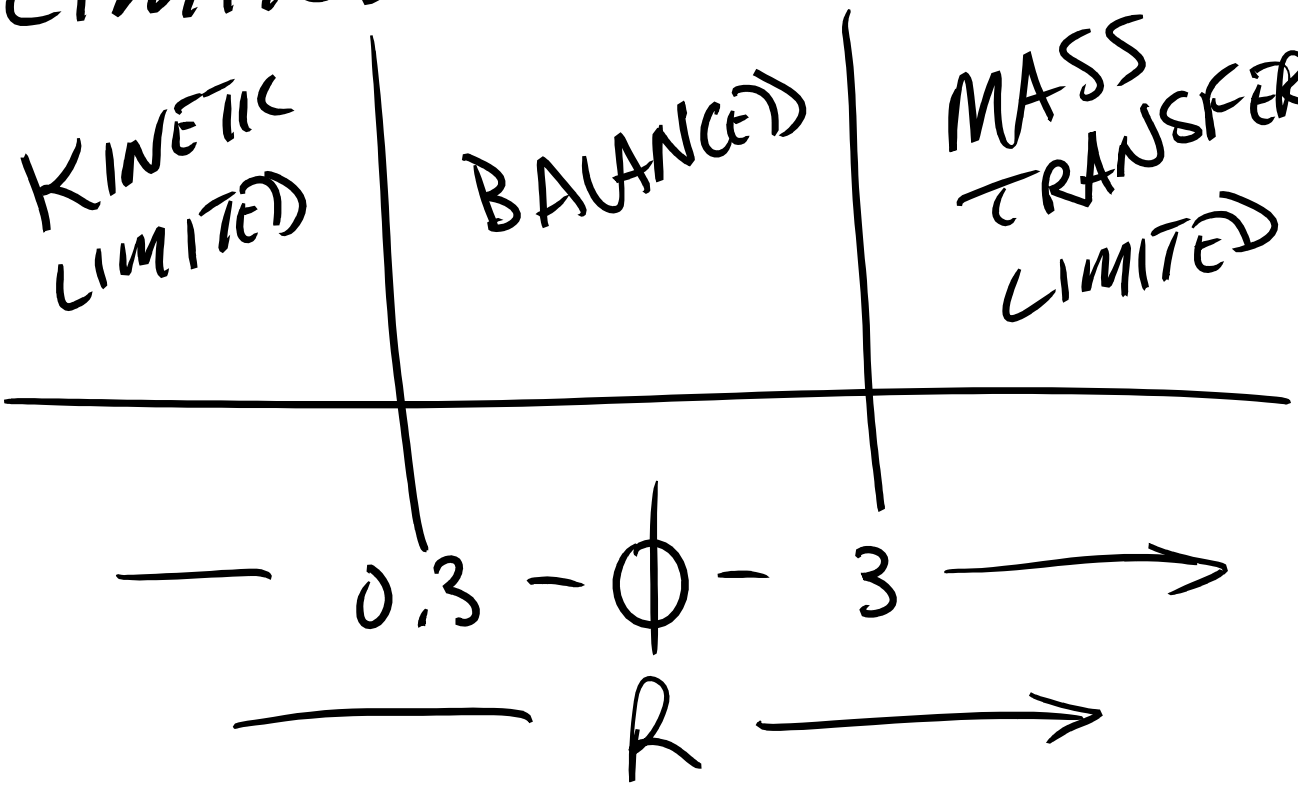
$k = 0.1185\ s^{-1}$

$S_{SURF} = 5.8\ mmol/L$

$D_{EFF} = 6.3 \times 10^{-6}\ cm^2/s$

"REACTION OCCURS INSIDE A POROUS CATALYST"

A) WHAT PARTICLE SIZE IS NEEDED TO ENSURE SYSTEM IS THE MASS TRANSFER LIMITED?



NOTE: SOME PROPOSE USING η AS BASIS FOR DETERMINING WHETHER SYSTEM IS KINETICALLY OR MASS TRANSFER LIMITED! ($\eta_I > 0.95$; $0.95 > \eta_I > 0.40$; $\eta_I < 0.40$)
KLIM MTLIM

WE WILL USE $\phi \leq 0.3$

$$\phi = \frac{R}{3}\sqrt{\frac{k}{D_{EFF}}}$$

$$0.3 = \frac{R}{3}\sqrt{\frac{0.118 s^{-1}}{6.3\times10^{-6} cm^2/s}}$$

$R = 0.0066 cm$

$D = 0.0132 cm = 132 \mu m$

NOTE FOR $\phi = 0.3$ $\quad \eta_I = \frac{1}{\phi}\left[\frac{1}{TANH(3\phi)} - \frac{1}{3\phi}\right]$

$$\eta_I = 0.95$$

B) IF $D = 250 \mu m$ WHAT IS η_I?

$R = 125 \mu m$

$= 0.0125 cm$

$$\phi = \frac{R}{3}\sqrt{\frac{k}{D_{EFF}}} = \frac{0.0125}{3}\sqrt{\frac{0.118}{6.3\times10^{-6}}}$$

$$\phi = 0.57$$

$$\eta_I = \frac{1}{\phi}\left[\frac{1}{TANH(3\phi)} - \frac{1}{3\phi}\right] = \frac{1}{0.57}\left[\frac{1}{TANH(1.71)} - \frac{1}{1.71}\right]$$

$$\eta_I = 0.847$$

c) $$x \equiv \frac{\sinh(3\phi\xi)}{\xi \sinh(3\phi)}$$

THIS EQUATION GIVES SUBSTRATE CONC (x) AS FUNCTION OF RADIUS (ξ).

WHAT ABOUT WHEN $\xi = 0$

$$x = \frac{\sinh(0)}{0 \cdot \sinh(3\phi)} = \frac{0}{0} \; ?$$

L'HOPITAL'S RULE

$$\lim_{\xi \to 0} x = \frac{\sinh(3\phi\xi)}{\xi \sinh(3\phi)} = \frac{3\phi \cosh(3\phi\xi)}{\sinh(3\phi)} \quad (\cosh = 1)$$

$$= \frac{3\phi}{\sinh(3\phi)}$$

So $$x = \frac{3\phi}{\sinh(3\phi)} = \frac{3(0.57)}{\sinh(3 \cdot 0.57)}$$

$$x = 0.639$$

$$S_o = (5.8\,\text{mM})(0.639) = 3.7\,\text{mM}$$

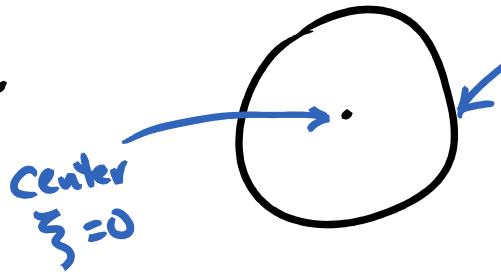
IF $$\eta_I = \frac{V_{ACTUAL}}{V_{MAX}} = \frac{kS_o}{kS_{SURF}} = \frac{S_o}{S_{SURF}}$$

$$0.847 = \frac{S_o}{5.8\,\text{mM}} \Rightarrow S_o = 4.9\,\text{mM}?$$

NO

η_I IS FOR ENTIRE PARTICLE NOT JUST AT CENTER!

NOTES:



WHERE CONC HAS DISTRIBUTION WITH SURFACE CONC. = S_{BULK}
BUT ELSEWHERE $S = f(r) = f(\xi)$

$$\eta_I = \frac{V_{ACTUAL}}{V_{MAX}}$$

IF WHOLE PARTICLE WERE AT SURFACE CONCENTRATION $\left(= k S_{SURF}\right)$

$$V_{ACTUAL} = \eta_I V_{MAX} = \eta_I k S_{SURF}$$