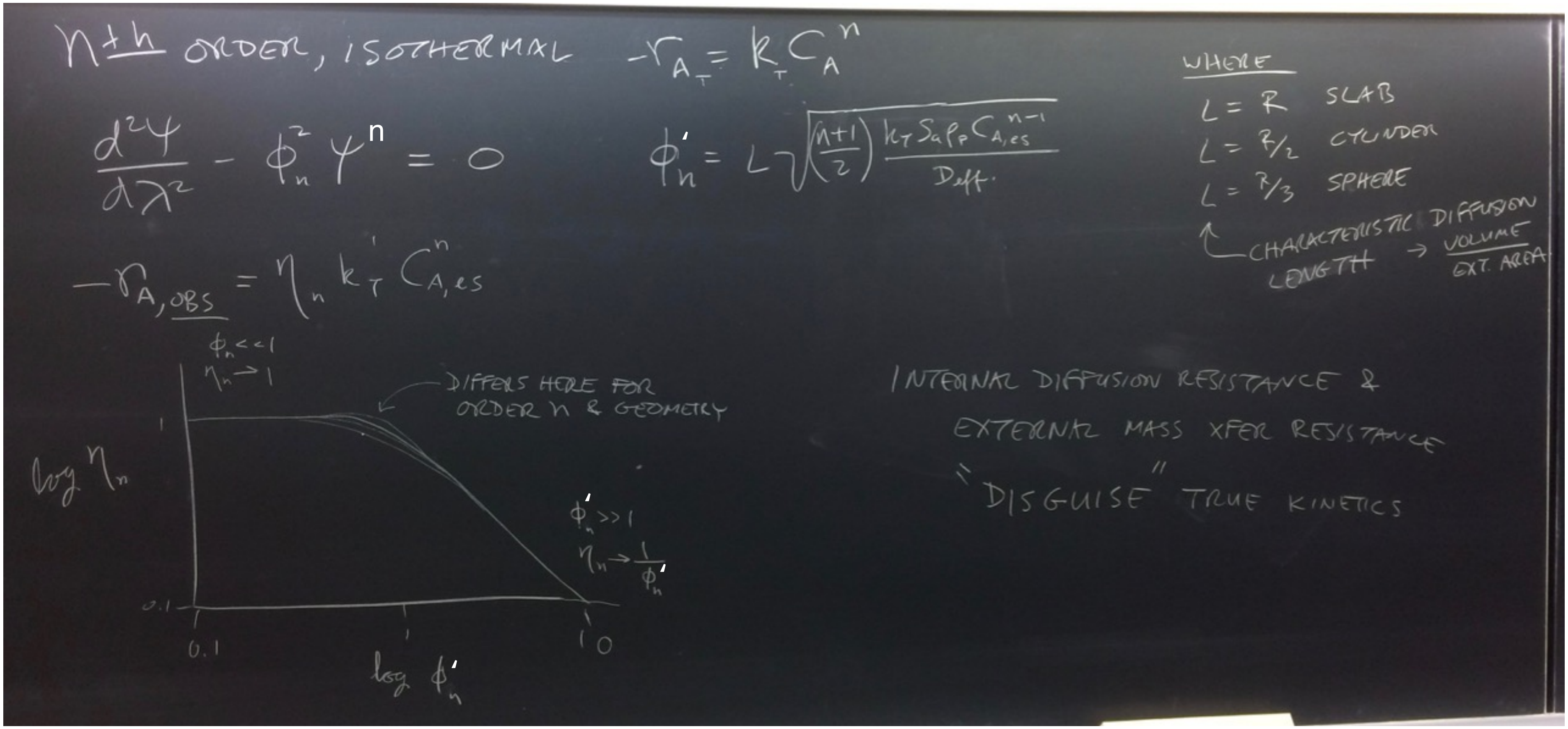
Before going to the blackboard, we
- looked at Grad CRE Notes, Diffusion resistance in methanol synthesis catalyst pellets
- the following labs in the desktop software Reactor Lab: D2L1, D2L2, D7L3



(?) FOR $n = 2$ & $\phi_n >> 1$, WHAT IS OBSERVED ORDER?

$$-r_{A,obs} = \frac{k_T' C_A^2}{L\sqrt{\left(\frac{n+1}{2}\right)\frac{k P S_a C_A^{n-1}}{D_{eff}}}} \propto \frac{C_A^2}{\sqrt{C_A}} = C_A^{3/2}$$

→ OBSERVED ORDER $n - \left(\frac{n-1}{2}\right)$

FOR $n = 1$ & $\phi_n >> 1$, OBSERVED ORDER IS 1

FOR $n = 0$ " , " " " 1/2

TRUE ORDER	OBSERVED ORDER
2	→ 3/2
1	→ 1
0	→ 1/2

n^{th} ORDER RXN COUPLED w/ 1^{st} ORDER DIFFUS → RXN MORE LIKE 1^{st} ORDER.

{FICK'S LAW — DIFFUSION CAN BE CONSIDERED 1^{st} ORDER PROCESS

$$\text{FLUX} = -D_{eff}\frac{dC}{dr} \approx -D_{eff}\frac{(C_A - 0)}{R}$$

(?) WHAT ABOUT OBSERVED ACTIVATION ENERGY?

FOR $\phi << 1$, $\eta \to 1$, OBS $\Delta E \to$ TRUE ΔE

FOR $\phi >> 1$, $\eta \to \frac{1}{\phi}$ OBS $\Delta E \to$?

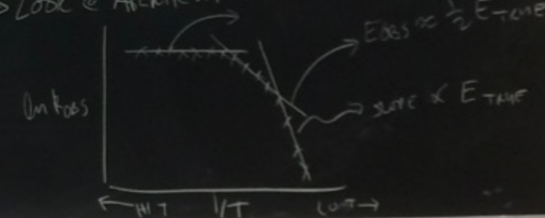
$$k_{obs} \propto \frac{k_T}{\sqrt{\frac{k_T}{D_{eff}}}} \propto \frac{e^{-E/kT}}{\sqrt{e^{-E/kT}}}$$

$D_{eff} \propto T^{\frac{1}{2}\text{ to }\frac{3}{2}}$

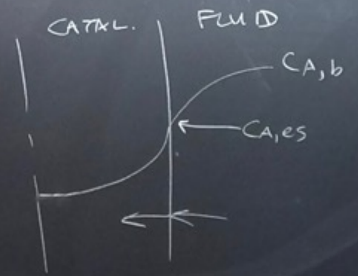
$E_{OBS} \approx \frac{1}{2} E_{TRUE}$

→ LOOK BACK TO PLOT ON 1^{st} SLIDE TODAY

→ LOOK @ ARRHENIUS PLOT



NOW ADD EXTERNAL MASS XFER RESISTANCE



e.g., 1st ORDER RXN

INTERNAL ACTIVE SITE AREA PER MASS

GEOMETRIC EXTERNAL AREA PER MASS CAT.

$$\eta k_T S_a C_{A,es} = k_m a_{es} (C_{A,b} - C_{A,es}) = -r_{A,obs}$$

$\frac{m}{s}$ $\frac{m^2}{kg}$ $\frac{mol}{m^3}$ $\qquad$ $\frac{m}{s}$ $\frac{m^2}{kg}$ $\frac{mol}{m^3}$

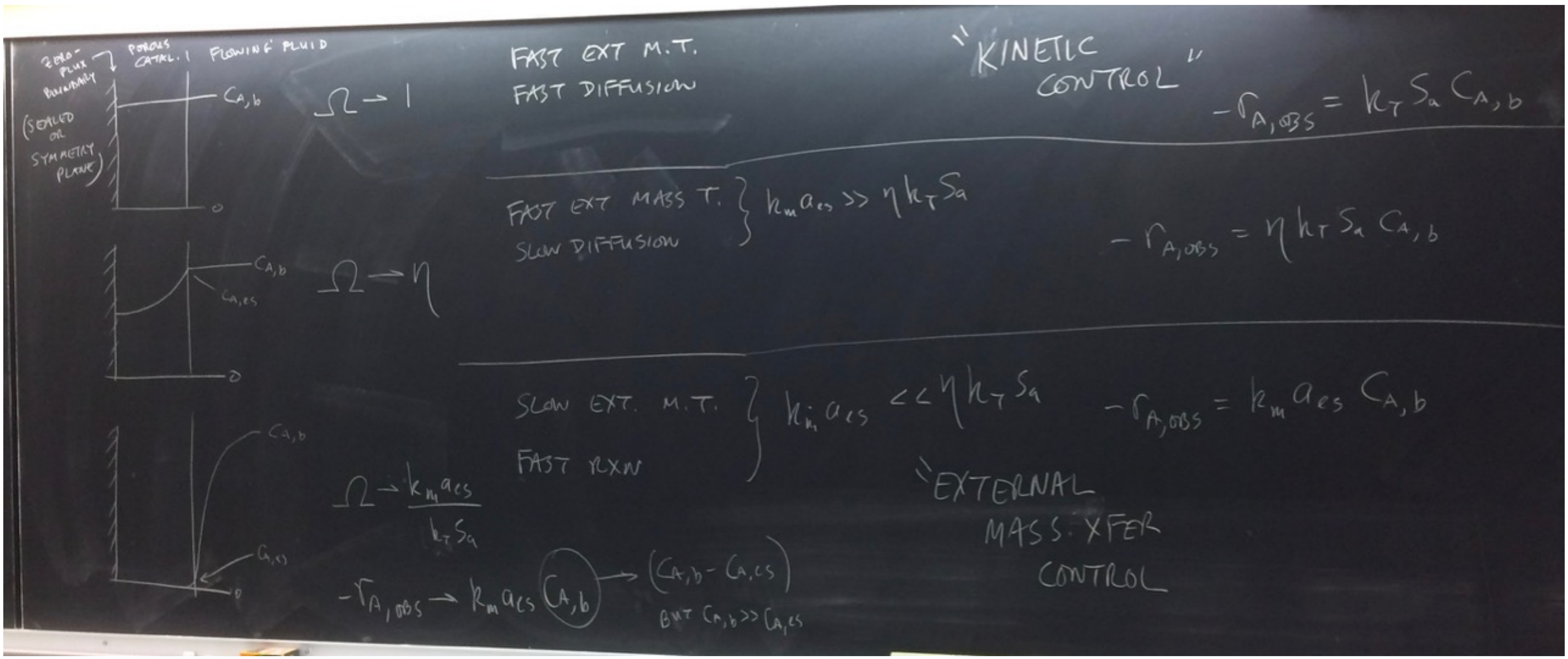
k_m ← EXTERNAL MASS XFER COEFFICIENT

SOLVE FOR $C_{A,es} = f(C_{A,b})$ & SUBSTITUTE BACK

$$-r_{A,obs} = \Omega k_T S_a C_{A,b}$$

Ω ← OVERALL EFFECTIVENESS FACTOR

$$\Omega = \frac{\eta k_m a_{es}}{k_m a_{es} + \eta k_T S_a}$$


ZERO-FLUX BOUNDARY
(SEALED OR SYMMETRY PLANE)
POROUS CATAL.
FLOWING FLUID
$C_{A,b}$
$\Omega \to 1$
FAST EXT M.T.
FAST DIFFUSION
"KINETIC CONTROL"
$-r_{A,OBS} = k_T S_a C_{A,b}$
FAST EXT MASS T.
SLOW DIFFUSION
$k_m a_{es} >> \eta k_T S_a$
$-r_{A,OBS} = \eta k_T S_a C_{A,b}$
$C_{A,b}$
$C_{A,es}$
$\Omega \to \eta$
SLOW EXT. M.T.
FAST RXN
$k_m a_{es} << \eta k_T S_a$
$-r_{A,OBS} = k_m a_{es} C_{A,b}$
"EXTERNAL MASS XFER CONTROL
$C_{A,b}$
$C_{A,es}$
$\Omega \to \frac{k_m a_{es}}{k_T S_a}$
$-r_{A,OBS} \to k_m a_{es} C_{A,b} \to (C_{A,b} - C_{A,es})$
BUT $C_{A,b} >> C_{A,es}$