$$\rho_G \frac{dV}{dt} + V \frac{d\rho_G}{dt} = Q^G \rho_G^G - Q^L \rho_G^L$$

FUNCTION OF t

FUNCTION OF t

WE WANT TO SOLVE FOR $\rho_G = f(t)$

IF TANK IS WELL-MIXED, THEN $\rho_G^L = \rho_G$

$$\rho_G [0.07] + [1.0 + 0.07t] \frac{d\rho_G}{dt} = (0.10)(12) - (0.03)\rho_G$$

REARRANGE:

$$(1.0 + 0.07t) \frac{d\rho_G}{dt} = 1.2 - 0.10\rho_G$$

$$\int_{p_{G0}}^{p_G} \frac{dp_G}{1.2 - 0.10 p_G} = \int_0^t \frac{dt}{1.0 + 0.07t}$$

$$-\frac{1}{0.10} \ln\left[\frac{1.2 - 0.10 p_G}{1.2 - 0.10 p_{G0}}\right] = \frac{1}{0.07} \ln\left[\frac{1.0 + 0.07t}{1.0 + 0.07(0)}\right]$$

$p_{G0} = 0$

$$\ln\left[\frac{1.2 - 0.10 p_G}{1.2}\right] = -1.42857 \ln\left[1.0 + 0.07t\right]$$

$$\frac{1.2 - 0.10 p_G}{1.2} = \left[1.0 + 0.07t\right]^{-1.42857}$$

i) WHAT IS t WHEN $\rho_G = 5$?

ii) WHAT IS V AT THAT TIME?

$\underline{t = 6.55 \text{ MIN}}$

$V = 1.0 + 0.07t$

$V = 1.0 + 0.07(6.55)$

$V = 1.46L$

BONUS QUESTION:

AT WHAT TIME WOULD CONC. BE 5 g/L IF THERE WERE NO LEAK?

$$\text{CONC} = \frac{\text{MASS}}{\text{VOLUME}}$$

$$\text{MASS} = \left(\text{VOLUME ADD}\right)\left(\text{CONC ADD}\right) = (.714L)\left(\frac{12g}{L}\right)$$

$$5 = \frac{(V_{ADD})(12)}{1 + V_{ADD}} \qquad V_{ADD} = 0.714L$$

SO, WITHOUT A LEAK THE FINAL VOLUME WOULD BE 1.714L

TIME TO REACH 1.714L $= \dfrac{0.714\,L}{0.1\,L/min} = \underline{7.14\ min}$

STARTED WITH 0 g/L GLUCOSE IN TANK

(V = 1.464) WITH LEAK 6.55 MIN TO REACH CONC. 5 g/L GLU

(V = 1.714L) WITHOUT LEAK 7.14 MIN TO REACH CONC. 5 g/L GLU

QUESTION 9

DRAW & LABEL

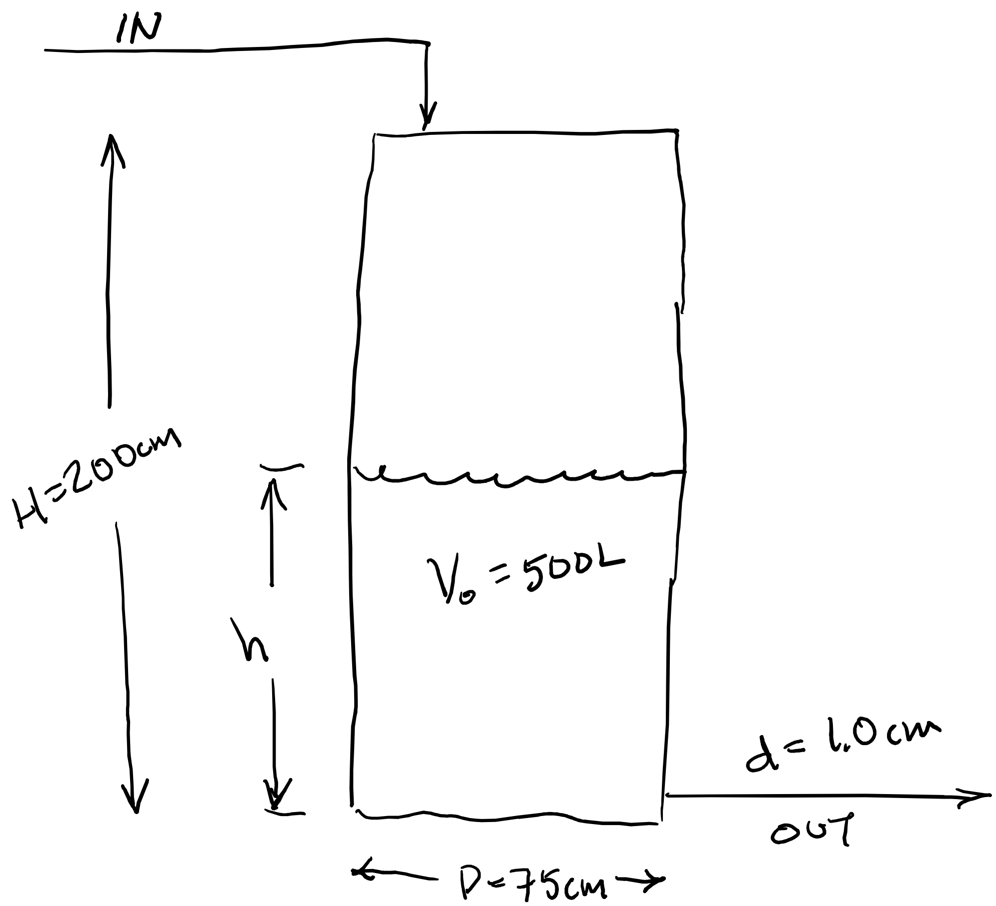
ETHANOL

$Q^{IN} = 12\ L/min$

$w_E^{IN} = 1.0$

$\rho_E^{IN} =$

$\rho^{IN} =$



ρ — DENSITY

ρ_E — CONC. OF ETHANOL.

ETHANOL/WATER MIXTURE

Q^{OUT}

w_E^{OUT}

ρ_E^{OUT}

ρ^{OUT}

IMPORTANT INFORMATION

VOLUME OF TANK $V_{TOT} = \frac{\pi D^2 H}{4} = \frac{(3.14)(75)^2(200)}{4} \times \frac{L}{1000 cm^3} = \underline{883.5 L}$

INITIAL LIQUID HEIGHT $h_o = \frac{4 V_o}{\pi D^2} = \frac{4(500)}{(3.14)(75)^2} \times \frac{1000 cm^3}{L} = \underline{113 cm}$

FROM LITERATURE DATA $\rho\ (g/cm^3) = f(w_E)$

$$\rho = 0.9690\, w_E^4 - 1.314\, w_E^3 + 0.4728\, w_E^2 - 0.1979\, w_E + 0.9982$$

$$0 \leq w_E \leq 0.60$$

OVERALL BALANCE

ACC = IN − OUT

ρ = DENSITY

$$\frac{d(V\rho)}{dt} = Q^{in}\rho^{in} - Q^{out}\rho^{out}$$

BOTH V & ρ ARE FUNCTIONS OF TIME!