a) ETHANOL BALANCE

$$ACC = IN - OUT + \cancel{GEN}^{0}$$

$$\frac{d(V\rho_E)}{dt} = \underbrace{(0.05)(5)}_{Kg/min} - Q^{DE}\rho_E^{DE}$$

THE VOLUME IS CONSTANT 30L

$$30\frac{d\rho_E}{dt} = 0.25 - Q^{DE}\rho_E^{DE}$$

ρ_E: CONC. OF ETHANOL IN TANK

ρ_E^{DE}: CONC. OF ETHANOL IN EXITING STREAM.

IF TANK IS WELL-MIXED THEN $\rho_E = \rho_E^{DE}$

$$30\frac{d\rho_E}{dt} = 0.25 - Q^{DE}\rho_E$$

$$30\int_{\rho_E^i}^{\rho_E^f}\frac{d\rho_E}{0.25 - Q^{DE}\rho_E} = \int_0^t dt$$

WHAT IS Q^{DE}? WHAT IS RELATIONSHIP BETWEEN Q^{DE} & ρ_E?

SINCE SOLUTION OF ETHANOL IS DILUTE, AND MASS FRACTION OF ETHANOL ONLY VARIES SLIGHTLY (3%-4%), WE MIGHT ASSUME THAT Q^{DE} IS A CONSTANT.

$$Q^{DE} = Q \sim Q^{IN} = \left(\frac{5.0\,kg}{min}\right)\left(\frac{mL}{0.9927\,g}\right)\left(\frac{g\,L}{kg\,mL}\right) = 5.037\frac{L}{min}$$

← DENSITY OF 5% ETHANOL SOLUTION

$$-\frac{30}{Q}\ln\left[\frac{0.25-Q\rho_E^{\,f}}{0.25-Q\rho_E^{\,i}}\right]=t$$

USE

$Q = 5.037$ L/min

0.25 – Kg/min

ρ_E = Kg/L

DENSITY 4% ETHANOL

$$\rho_E^{\,f}(4\%\ \text{ETHANOL}) = \left(\frac{0.04\,g\ E}{g\ SOLN}\right)\left(\frac{0.9911\,g\ SOLN}{mL\ SOLN}\right)\left(\frac{mL\ Kg}{L\ g}\right)$$

$$= 0.03964\ Kg/L$$

$$\rho_E^{\,i}(3\%\ \text{ETHANOL}) = \left(\frac{0.03\,g\ E}{g\ SOLN}\right)\left(\frac{0.9927\,g\ SOLN}{mL\ SOLN}\right)\left(\frac{mL\ Kg}{L\ g}\right)$$

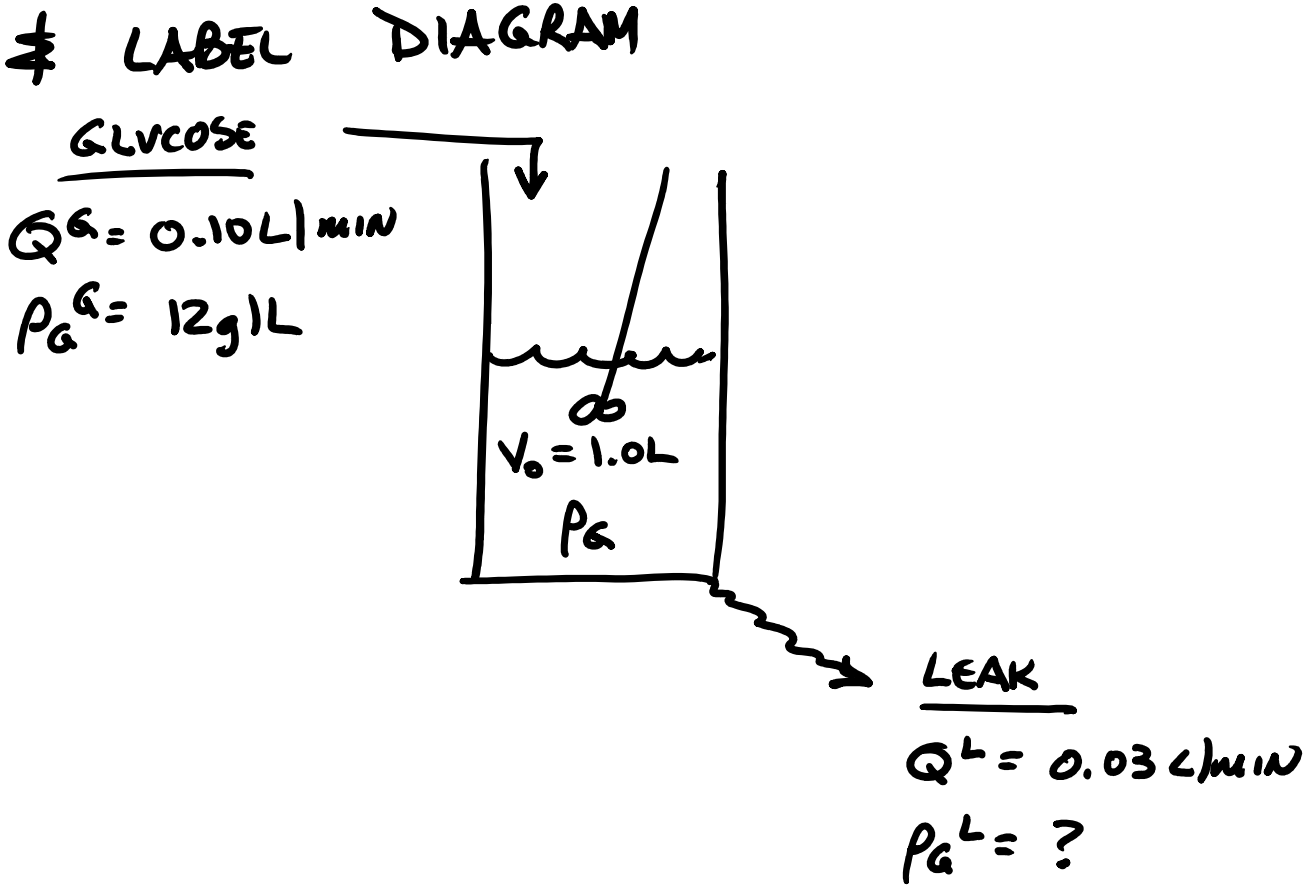
$$= 0.02973\ Kg/L$$

$$-\frac{30}{5.037}\ln\left[\frac{0.25-0.03964(5.037)}{0.25-0.02973(5.037)}\right] = t = \underline{4.1 \text{ MINUTES}}$$

NOTE Q = CONSTANT?

FOR 4% ETHANOL Q = 5.045 L/MIN AND ANSWER WOULD CHANGE BY 0.017 MINUTES (~ 1 SECOND, 0.4% ERROR)

DRAW & LABEL DIAGRAM



OVERALL BALANCE

$$\text{ACC} = \text{IN} - \text{OUT}$$

$$\frac{dm}{dt} = \frac{d(V\rho)}{dt} = Q^G \rho^G - Q^L \rho^L$$

ρ = DENSITY OF SOLUTION IN TANK (CHANGING)

ρ^G = DENSITY OF SOLUTION IN GLUCOSE FEED (CONSTANT)

ρ^L = DENSITY OF SOLUTION IN LEAK (CHANGING)

$$\rho = \rho^G = \rho^L = \text{CONSTANT}$$

$$\frac{dV}{dt} = Q^G - Q^L$$

$$\int_{V_0}^{V} dV = \int_0^t (Q^a - Q^d)\,dt = \int_0^t (0.10 - 0.03)\,dt$$

$$V - V_0 = 0.07t$$

V [L] t [min]

OR $V = 0.07t + V_0$

$$\boxed{V = 0.07t + 1.0}$$

NOTE

$$\boxed{\frac{dV}{dt} = 0.07}$$

GLUCOSE BALANCE

$$ACC = IN - OUT + \cancel{GEN}^{0}$$

$$\frac{d(V\rho_G)}{dt} = Q^G \rho_G^G - Q^L \rho_G^L$$

NOTE: BOTH V & ρ_G ARE $f(t)$!

THESE ARE CONCENTRATIONS (SUBSCRIPT G)

NOT DENSITIES.

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