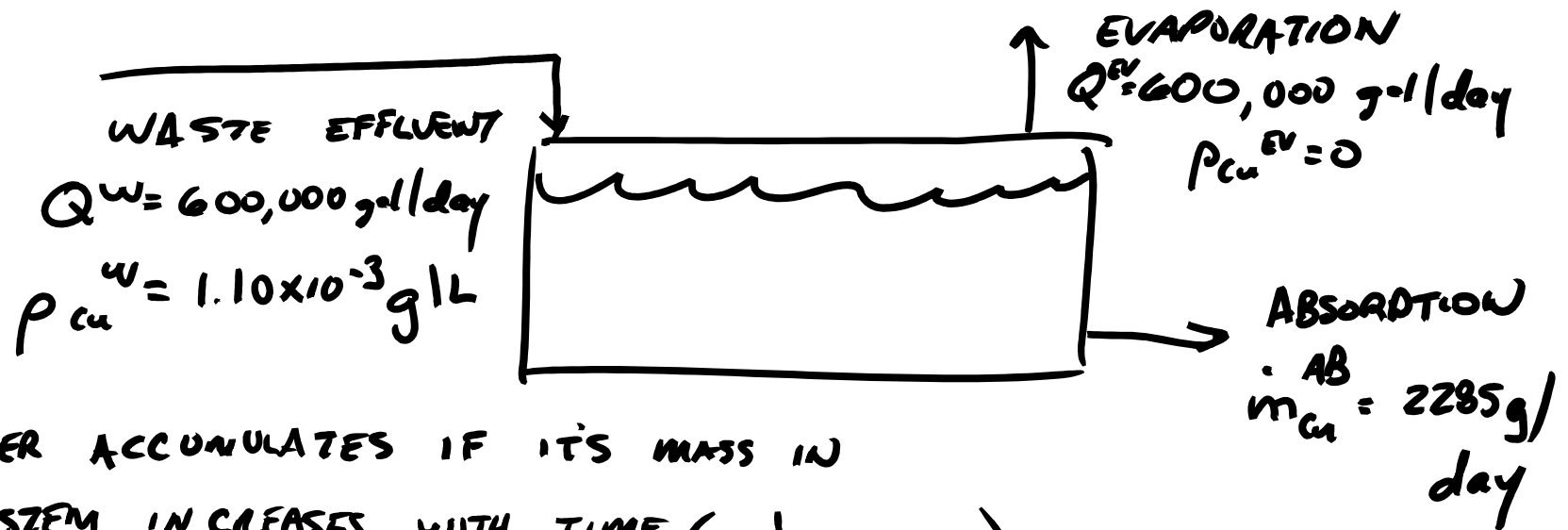


c) UNREACTIVE & UNSTEADY-STATE
↑
(ACC ≠ 0)

QUESTION 5 - DRAW & LABEL



COPPER ACCUMULATES IF ITS MASS IN
SYSTEM INCREASES WITH TIME $\left(\frac{dm_{Cu}}{dt} > 0 \right)$

OVERALL BALANCE (?)

DOES NOT ACCOMPLISH MUCH... THE TOTAL VOLUME DOESN'T CHANGE. COPPER IS THE KEY COMPONENT.

COPPER BALANCE:

$$ACC = IN - OUT + GEN$$

NO REACTION

MASS

$$\frac{dm_{Cu}}{dt} = \frac{d(\rho_{Cu} V)}{dt} = \dot{m}_{Cu}^W - \dot{m}_{Cu}^{EV} - \dot{m}_{Cu}^{AB}$$

IN THIS SYSTEM VOLUME (V) IS A CONSTANT

ACC IS

$$\frac{V d\rho_{Cu}}{dt}$$

ALSO, EACH MASS FLOWRATE ($\dot{m}$) CAN BE REPRESENTED BY

A FLOWRATE (Q) TIMES A CONCENTRATION (P_{Cu}):

$$V \frac{dP_{Cu}}{dt} = Q^w P_{Cu}^w - \underbrace{Q^{EV} P_{Cu}^{EV}}_{\text{ZERO}} - m_{Cu}^{AB}$$

NOTE: P_{Cu} = CONC OF Cu IN THE RESERVOIR

P_{Cu}^w = CONC OF Cu IN THE STREAM "WASTE EFFLUENT"

$$1.26 \times 10^9 \text{ gal} \frac{dP_{Cu}}{dt} = \left(600,000 \frac{\text{gal}}{\text{day}} \right) \left(\frac{1.1 \times 10^{-3} \text{ g}}{\text{gal}} \right) \left(\frac{3.785 \text{ L}}{\text{gal}} \right) - 2285 \frac{\text{g}}{\text{day}}$$

$$1.26 \times 10^9 \text{ gal} \frac{d p_{cu}}{dt} = 0.213 \text{ g/day}$$

$$\frac{d p_{cu}}{dt} = 1.691 \times 10^{-7} \frac{\text{g}}{\text{gal day}}$$

POSITIVE SIGN

NOTES: STRANGE UNIT, BUT THE KEY POINT IS THAT
THE VALUE IS POSITIVE. ANSWER TO PART i) "YES"

PART ii)

$$\frac{d p_{cu}}{dt} = 1.691 \times 10^{-7} \frac{\text{g}}{\text{gal day}}$$

$$100 \text{ ppb} \rightarrow 100 \times 10^{-6} \text{ g/L}$$

$$\int dp_{cu} = \left(\frac{\text{gal}}{3.785 \text{ L}} \right) \int_0^t 1.691 \times 10^{-7} dt$$

$$20 \text{ ppb} \rightarrow 20 \times 10^{-6} \text{ g/L}$$

$$p_{cu} \left| \begin{array}{l} 100 \times 10^{-6} \\ 20 \times 10^{-6} \end{array} \right. = 4.468 \times 10^{-8} t$$

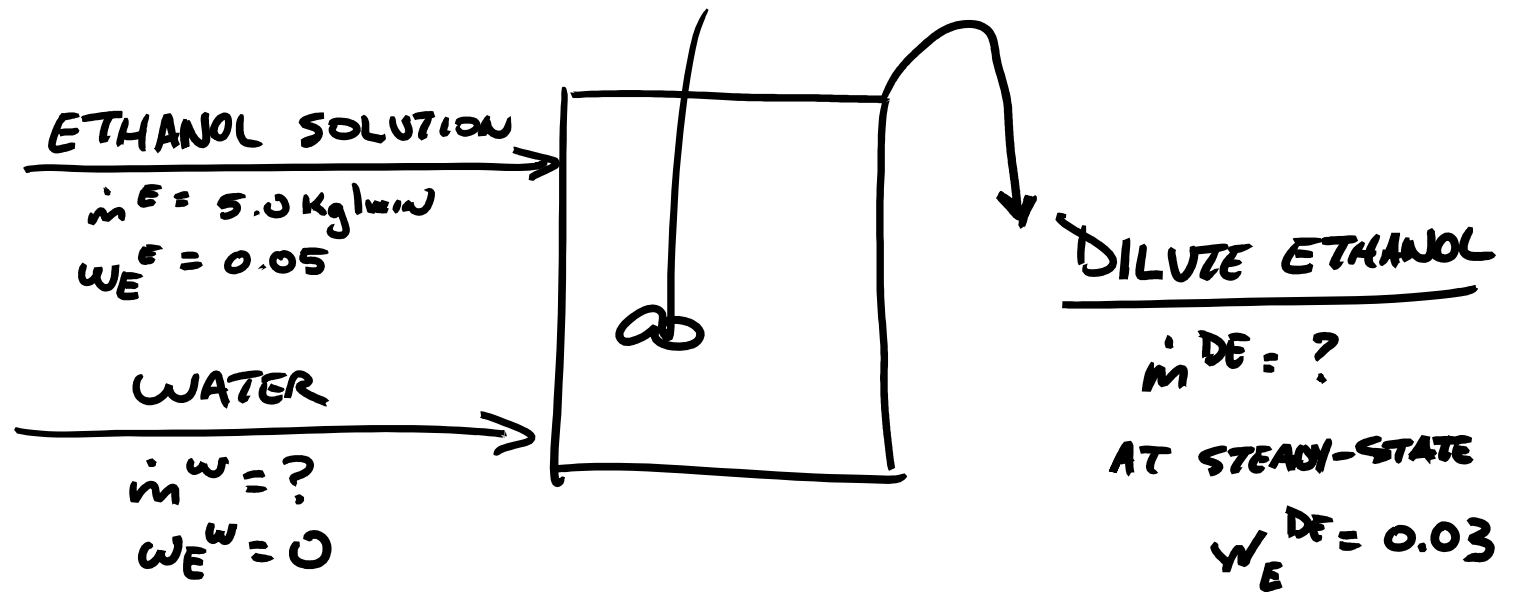
$$80 \times 10^{-6} = 4.468 \times 10^{-8} t$$

$$\underline{t = 1790 \text{ days}}$$

ACCUMULATION GIVES US A RATE. ONLY WAY TO CALCULATE
A CONCENTRATION AT A (FUTURE) TIME IS TO BE GIVEN
THE CONCENTRATION AT ANOTHER TIME (PRESENT).
ALTERNATIVELY, WE COULD CALCULATE TIME REQUIRED
TO CHANGE FROM ONE CONC. TO ANOTHER, AS WE DID
HERE.

QUESTION 6

DRAW & LABEL DIAGRAM:



i) STEADY-STATE SOLUTION

a) ETHANOL BALANCE

$$\begin{aligned} ACC &= IN - OUT + GEN \\ 0 &= (0.05)(5.0 \text{ Kg/min}) + 0 \\ &\quad - 0.03 \dot{m}^{DE} \end{aligned}$$

$$\dot{m}^{DE} = 8.33 \text{ Kg/min}$$

b) OVERALL BALANCE

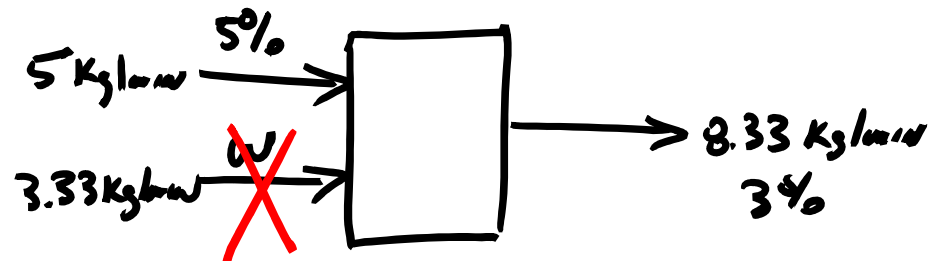
$$\begin{aligned} ACC &= IN - OUT \\ 0 &= 5 + \dot{m}^W - 8.33 \\ \dot{m}^W &= 3.33 \text{ Kg/min} \end{aligned}$$

ii)

UNSTEADY-STATE SOLUTION

WHAT IS GOING ON HERE?

AT $t=0$ STREAM
W IS TERMINATED



AND SYSTEM RESPONDS

