Problem 1: (20%)

雷諾數 (Reynolds number) 爲一無因次群。當流體在一管中流動時，其定義如下：

$$Re = Du\rho/\mu$$

ρ 為密度

其中 D 是管之直徑，u 是流體速度，μ 是流體黏滯度。當流體之雷諾數小於 2100 時，稱爲層流 (laminar flow)，即表示流體分層平滑流動；當雷諾數大於 2100 時，稱爲紊流 (turbulent flow)，流體有激烈擾動之特性。

液態 MEK (methyl ethyl ketone) 流經一圓管，其直徑爲 2.067 in.，平均流速爲 0.48 ft/s。在 20°C 時，MEK 之密度爲 0.805 g/cm³，黏滯度爲 0.43 cP [1 cP = 1.00×10^{-3} kg/(m · s)]。

(A) 計算 Re 值。

(B) 試判別此液体在管中流动之情形爲屬於層流或紊流。

where : 1 m = 3.2808 ft = 39.37 in = 100 cm

1 kg = 1000 g

Problem 2: (20%)

The density of a fluid is given by the empirical equation

$$\rho = 1.13 \exp(1.2 \times 10^{-10} P)$$

where ρ=density (g/cm³), and P=pressure(N/m²)

(a) What are the units of 1.13 and 1.2×10^{-10} ?

(b) Derive the formula for ρ' as a function of P' in English units ? Where $\rho' = \frac{lb_m}{ft^3}$ and $P' = lb_f/in^2$.

where : 1 lb = 453.6 g

1 N = 0.2248 lb_f

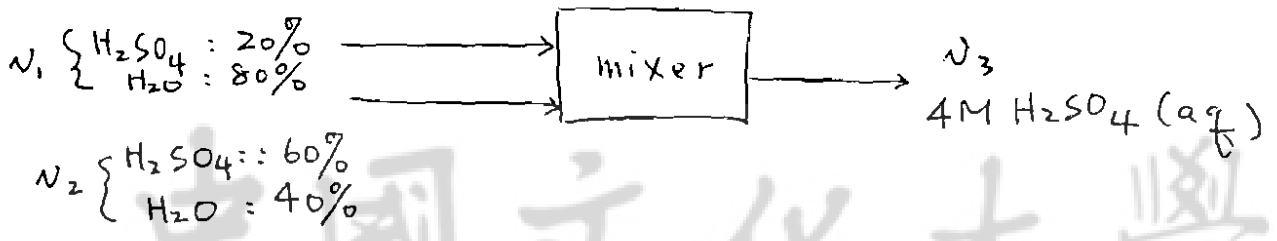
$g_c = 1 \frac{kg\ m}{s^2 N}$

Problem 3: (20%)

兩個硫酸水溶液含有 20wt% H_2SO_4 (SG=1.139) 和 60wt% H_2SO_4 (SG=1.498)。將兩者混合形成一 4.0M 的溶 (SG=1.213)。以 20% 的溶液 100kg 為基量，計算：

(a) 進料 60wt% H_2SO_4 所需的体積 V_2 (liter)?

(b) 混合後 4M H_2SO_4 溶液所生產的体積 V_3 (liter)?



where: $1M = 1\frac{mole}{l}$, $MW_{H_2SO_4} = 98\frac{g}{mole}$, $\rho_{H_2O} = 1\frac{g}{cm^3}$

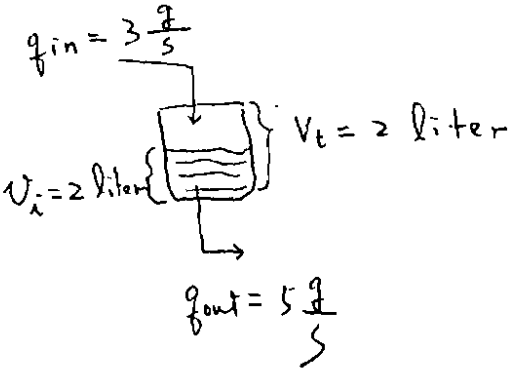
Problem 4: (20%)

Water enter a two-liter tank at a rate of $3\frac{g}{s}$ and is withdraw at a rate of $5\frac{g}{s}$. The tank is initially half full.

(a) Is this process batch, continuous or semibatch?

(b) Is it steady or unsteady?

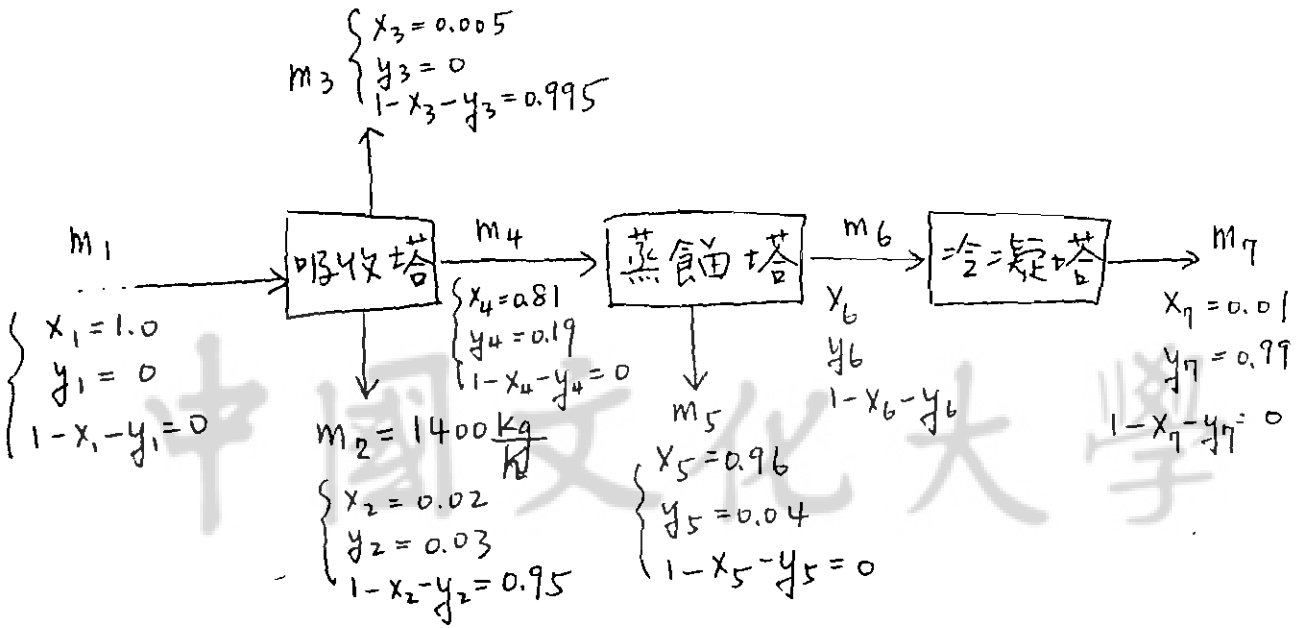
(c) Write a material balance for this process, solve the balance equation to determine how long (sec) it will take the tank to drain completely.



Where $\rho_{H_2O} = 1\frac{g}{cm^3}$

Problem 5: (20%)

下圖為一標示的穩態三單元程序的流程圖：



where x = water

y = Acetone

1-x-y = Air

求 m_1, m_3, m_4, m_5, m_7 的流量