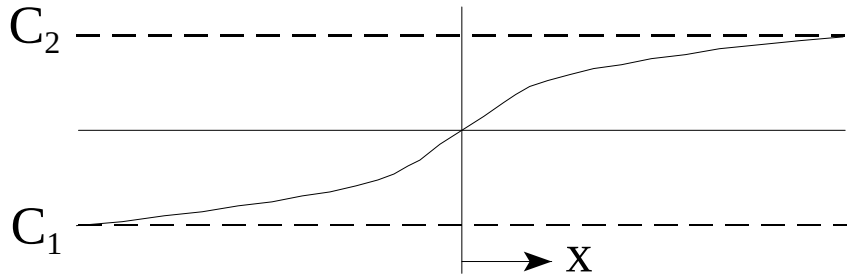
An infinite diffusion couple is set up by placing a block of Cu-5wt%Zn (on left in the figure below) in intimate contact with one of Cu-30wt%Zn (on right) at a temperature of 800 ^{o}C. Mass conservation (Fick's Second Law) and the boundary and initial conditions for this system are:

$$D\frac{\partial^2 C}{\partial y^2} = \frac{\partial C}{\partial t}$$

$$C(x \to -\infty) = C_1 = 5\,\text{wt\% Zn} \qquad C(x \to \infty) = C_2 = 30\,\text{wt\% Zn} \qquad \left.\frac{\partial C}{\partial x}\right|_{x \to \pm\infty} = 0$$



(a) Normalize the equation and the boundary conditions using these quantities:

$$\Gamma = \frac{C - C_1}{C_2 - C_1} \qquad \eta = \frac{x}{\delta(t)}.$$

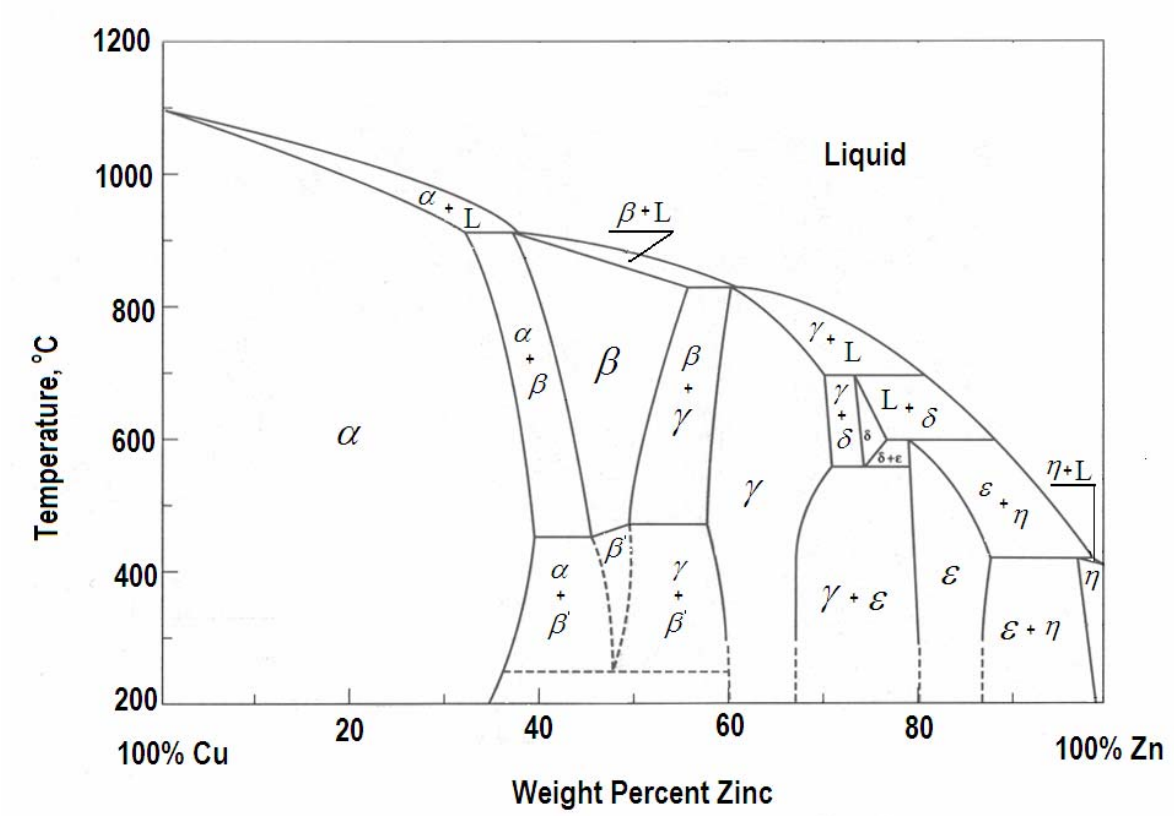
(b) Using a cubic polynomial for the composition profile, find an expression for $\delta(t)$. (Hint: When integrating the conservation equation, only examine the region between $x = 0$ and $x = \delta$.)

(c) How deep is the penetration depth after one day? ($D = 1.5 \times 10^{-14}$ m^2/s)

(d) This diffusion couple has no phase change in it. If C_2 = 50wt%Zn, how many phases would be present? (You'll need to look up the Cu-Zn phase diagram) Would this increase or decrease the rate of penetration into the blocks?

REFERENCE MATERIAL

*** Cu-Zn binary phase diagram**



The copper-zinc binary phase diagram. (Adapted from Metals Handbook: Metallography, Structures and Phase Diagrams, Vol. 8, 8th, ASM Handbook Committee, T. Lyman, Editor, American Society for Metals, 1973, p.301.)