Differential Distillation

First, we will deal with binary differential distillation. A liquid mixture is charged into the still and it is vaporized and it is immediately drawn off and condensed. We assume the vapor leaving the liquid is in equilibrium and the holdup of the vapor in the still is negligible. The process is carried out at constant pressure. As the vaporization proceeds, the more volatile component gets depleted and the temperature in the still increases. The processes can be described mathematically as follows.

Let the charge be a binary mixture and its initial amount be F. The boiling of the mixture generates bubbles which vigorously mix the charge and the vapor leaving it is in equilibrium with the liquid in the still. The vapor is drawn and the liquid in the still be L at time t. The unsteady-state differential solute balance around the still yield

$$\frac{d(Lx)}{dt} = -\dot{V}y$$

or

$$d(Lx) = -\dot{V}dty$$

By setting $dV = I\&l$, we can write Eq. 83 as

$$Ldx + xdL = -dVy$$

Noting that $dL = -dV$, we can rearrange Eq. 85 as

$$\int_F^L \frac{dL}{L} = \int_{x_F}^{x} \frac{dx}{y-x}$$

On integration we get

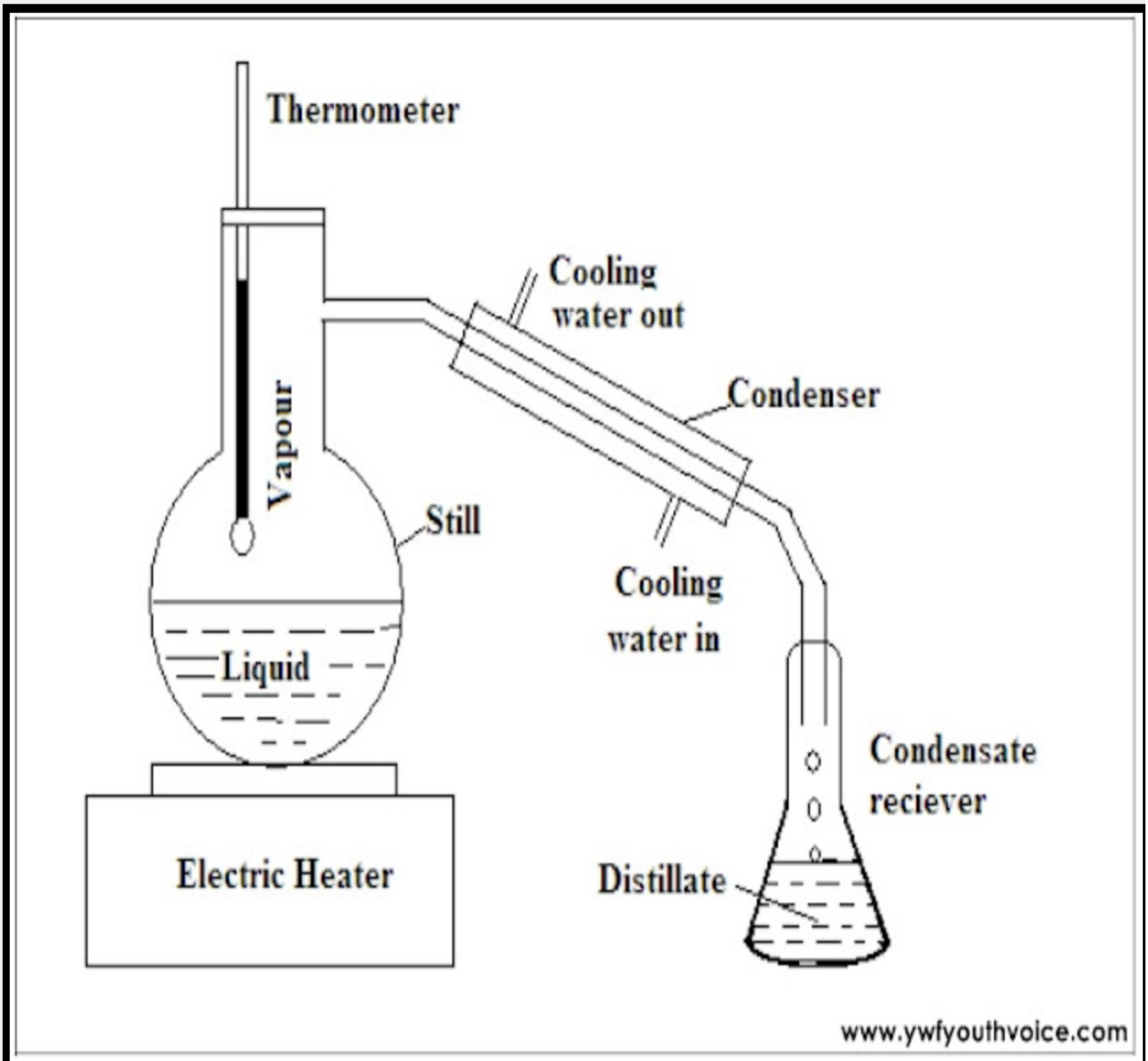
$$\ln\frac{L}{F} = \int_{x_F}^{x} \frac{dx}{y-x}$$

The integral on the left can be evaluated if the k is independent of x, which is true in the case of an ideal solution of two close boiling liquids. The integral form the equation is

$$\ln\frac{L}{F} = \frac{1}{k-1}\ln\left(\frac{x}{x_F}\right)$$

Alternately, we consider that α for the mixture is constant and integrate Eq. 87 to yield

$$\ln\frac{L}{F} = \frac{1}{\alpha-1}\left[\ln\frac{x_F}{x} + \alpha\ln\left(\frac{1-x}{1-x_F}\right)\right]$$



Simple batch or differential distillation process