CAPILLARITY

Capillarity is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. The rise of liquid surface is known as capillary rise, while the fall of the liquid surface is known as capillary depression.

EXPRESSION FOR CAPILLARY RISE:

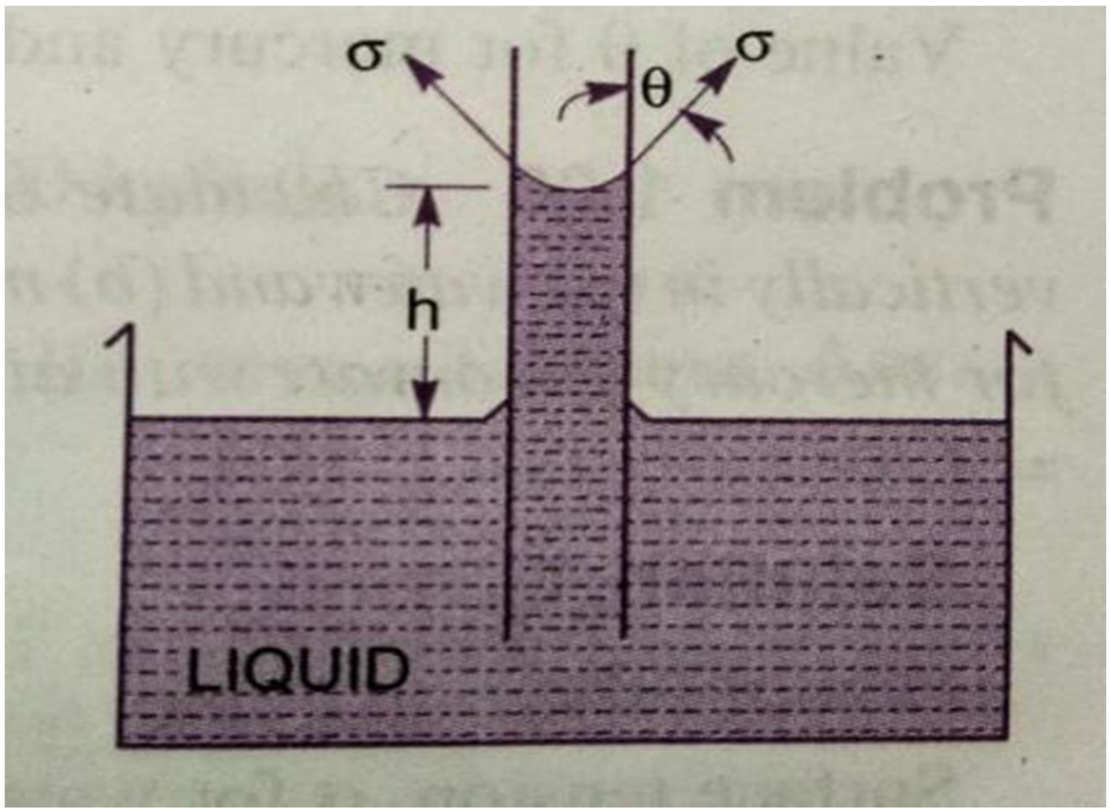
Consider a glass tube of small diameter‘d’ opened at both ends and is inserted in a liquid; the liquid will rise in the tube above the level of the liquid outside the tube.

Let ‘h’ be the height of the liquid in the tube. Under a state of equilibrium, the weight of the liquid of height ‘h’ is balanced by the force at the surface of the liquid in the tube. But, the force at the surface of the liquid in the tube is due to surface tension.

Let σ = surface tension of liquid

Θ = Angle of contact between the liquid and glass tube

$$h = 4\sigma / (\rho \times g \times d)$$



The weight of the liquid of height 'h' in the tube

$$= (\text{area of the tube} \times h) \times \rho \times g = \frac{\pi}{4} d^2 \times h \times \rho \times g$$

Where 'ρ' is the density of the liquid.

The vertical component of the surface tensile force = ($\sigma \times$ circumference) $\times \cos\theta = \sigma \times \pi d \times \cos\theta$

For equilibrium, $\frac{\pi}{4} d^2 \times h \times \rho \times g = \sigma \pi d \cos\theta$, $\quad h = \frac{\varsigma \pi d \cos\theta}{\frac{\pi}{4} d^2 \rho \times g} = \frac{4\varsigma \cos\emptyset}{\rho \times g \times d}$.

The value of θ is equal to '0' between water and clean glass tube, then $\cos\theta = 1$, $\quad h = \frac{4\sigma}{\rho \times g \times d}$

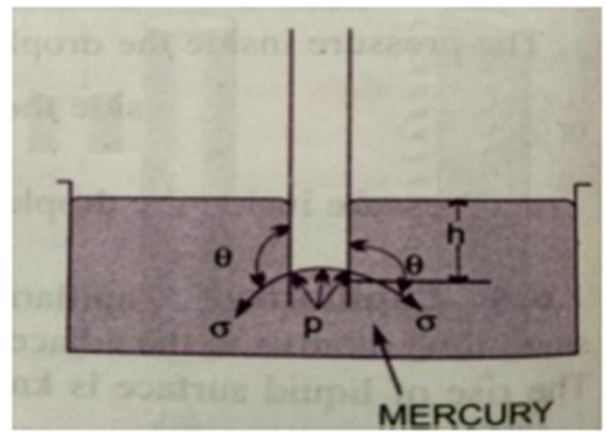
EXPRESSION FOR CAPILLARY FALL:

If the glass tube is dipped in mercury, the Level of mercury in the tube will be lower than the general level of the outside liquid.

Let, h = height of the depression in the tube. Then, in equilibrium, two forces are acting on the mercury inside the tube. First one is due to the surface tension acting in the downward direction =

$\varsigma \times \pi d \times \cos\theta$

The second force is due to hydrostatic force acting upward and is equal to intensity of pressure at a depth 'h' × area $= p \times \frac{\pi d^2}{4} = \rho g h \frac{\pi d^2}{4}$ $(p = \rho g h)$,



$$\sigma \pi d \cos\Theta = \rho g h \frac{\pi d^2}{4}$$

(The value of Θ for glass and mercury 128^0)

$$h = \frac{\varsigma \pi d \cos\theta}{\rho g h \frac{\pi d^2}{4}}$$

$$\mathbf{h} = \frac{\boldsymbol{os\theta}}{\boldsymbol{\rho g d}}$$