Ascent Formula.

When one end of capillary tube of radius r is immersed into a liquid of density d which wets the sides of the capillary tube (water and capillary tube of glass), the shape of the liquid meniscus in the tube becomes concave upwards.

R = radius of curvature of liquid meniscus.

T = surface tension of liquid

P = atmospheric pressure

Pressure at point A = P, Pressure at point B = $P - \frac{2T}{R}$



Pressure at points C and D just above and below the plane surface of liquid in the vessel is also P (atmospheric pressure). The points B and D are in the same horizontal plane in the liquid but the pressure at these points is different.

In order to maintain the equilibrium the liquid level rises in the capillary tube up to height h.

Pressure due to liquid column = pressure difference due to surface tension

 $\Rightarrow \qquad hdg = \frac{2T}{R}$ $\Rightarrow \qquad h = \frac{2T}{Rdg} = \frac{2T\cos\theta}{rdg} \qquad \left[\operatorname{As} R = \frac{r}{\cos\theta} \right]$ $\therefore \qquad h = \frac{r}{Rdg} = \frac{2T\cos\theta}{rdg} \qquad \left[\operatorname{As} R = \frac{r}{\cos\theta} \right]$

Important points

(i) The capillary rise depends on the nature of liquid and solid both i.e. on T, d, θ and R.

(ii) Capillary action for various liquid-solid pair.

Meniscus	Angle of contact	Level
Concave	θ< 900	Rises



Silver Water	Plane	θ = 900	No rise no fall
Glass	Convex	θ> 90ο	Fall

(iii) For a given liquid and solid at a given place

$$h \propto \frac{1}{r}$$
 [As T, θ , d and g are constant]

i.e. lesser the radius of capillary greater will be the rise and vice-versa. This is called Jurin's law.

(iv) If the weight of the liquid contained in the meniscus is taken into consideration then more accurate ascent formula is given by

$$h = \frac{2T\cos\theta}{rdg} - \frac{r}{3}$$

(v) In case of capillary of insufficient length, i.e., L < h, the liquid will neither overflow from the upper end like a fountain nor will it tickle along the vertical sides of the tube. The liquid after reaching the upper end will increase the radius of its meniscus without changing nature such that:

$$hr = Lr' :: L < h$$
 $\therefore r' > r$

(vi) If a capillary tube is dipped into a liquid and tilted at an angle α from vertical, then the vertical height of liquid column remains same whereas the length of liquid column (I) in the capillary tube increases.





 $h = l \cos \alpha$ or $l = \frac{h}{\cos \alpha}$

(vii) It is important to note that in equilibrium the height h is independent of the shape of capillary if the radius of meniscus remains the same. That is why the vertical height h of a liquid column in capillaries of different shapes and sizes will be same if the radius of meniscus remains the same.

