2

Q. Calculate the Amount of work Done in belowing the soap bubble of Diameter 2 cm. Surface Tension of Soap Solution $= 1.9 \times 10^{-2}$ N/m.

$\Rightarrow$ Diameter $= \dfrac{0.02}{2} = \underline{0.01}$ m

~~Ex. ...~~

$\cancel{W = T A}$

$\cancel{W = 1.9 \times 10^{-2} \times 0.0}$

$\cancel{W = 0.9}$

$W = T \cdot A$

$\Rightarrow W = T \cdot 2\pi R^2$

$W = 1.9 \times 10^{-2} \times 8 \times 3.14 \times 1 \times 10^{-4}$

$W = 1.9 \times 2 \times 2.14 \times 10^{-6}$

$W = 1.9 \times 2.5 \times 10^{-6}$

$W = 4.75 \times 10^{-6}$

$0.07 \times 0.07 = 49 \quad 0.0049$

Q. The Radius of bubble of Soap Solution is 5 cm. How Much work is Needed to increase it to 7 cm. The Surface Tension of Soap Solution is 0.03 ~~×10~~ N/m.

$\Rightarrow W = T \Delta A$

$\Rightarrow \Delta A = 8\pi (R_2^2 - R_1^2)$

$\Delta A = 8\pi (0.0049 - 0.0025)$

$= 8\pi \times 0.0024$

$\Delta A \Rightarrow \underline{0.0192\pi}$

$0.0049 - 0.0025 = .0024 \times 8 = .0192$

$W = 0.03 \times 0.0192 \times \pi$

$=$

Q. A Drop of water of Diameter = 0.2 cm is Split into 27000 Droplets of Same size. Assuming The Temperature to Remain Constant to Work Due. Surface tension of Water = 7×10^{-2} N/m

$$W = 4\pi R^2 T \cdot \left(n^{\frac{1}{3}} - 1\right)$$

$R = 1 \times 10^{-3}$ m

$\Rightarrow$

$$W = 4 \times \pi \times 1 \times 10^{-3} \times 1 \times 10^{-3} \times 7 \times 10^{-2} \left(\cancel{30}^{\cancel{3} \times \frac{1}{3}} - 1\right)$$

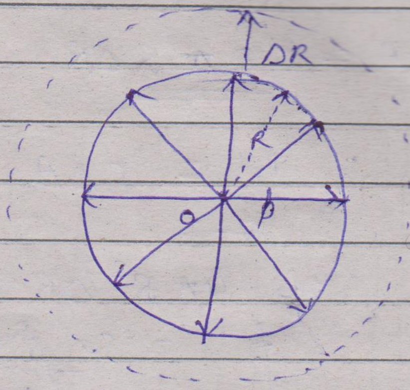
$$W = 4 \times 3.14 \times 1 \times 10^{-6} \times 7 \times 10^{-2} \times 29$$

$$W = 12.56 \times 10^{-6} \times 7 \times 10^{-2} \times 29$$

$W =$ ~~[illegible] × 29~~

2.55×10^{-5}

Q. Derive the expression for axis pressure inside Liquid Drop.



Consider a Liquid drop of Radius R The Molecules lying on the Surface of Liquid Drop due to Surface Tension will experience a Resultant force acting inwards ⊥ to the Surface. Since the size of Liquid Drop cannot be Reduced zero Due to force of Surface Tension therefore the pressure inside the Drop Must be greater than the pressure outside This the exces of pressure Inside the drop will provide a force acting outward ⊥ to the Surface, counter balance The Resultant force due to Surface Tension.

Let S Surface Tension of Liquid Drop
p equal Axis of pres- inside the Drop
ΔR = Increase in Radius of the Drop due to Axis of pressure,

Then work done by the Axes pressure

$W = F \times \text{displacement}$

~~W = F =~~ ,

$W = \text{displacement} \times \text{Area} \times \text{increase in Radius},$

$W = p \times 4\pi R^2 \times \Delta R$ — (1)

Increase in Surface Area of Drop = final Surface area − initial Surface area.

$\Delta A = 4\pi (R+\Delta R)^2 - 4\pi R^2$

$\Delta A = 4\pi \left[(R+\Delta R)^2 - R^2 \right]$

$\Delta A = 4\pi \left[R^2 + (\Delta R)^2 + 2R\Delta R - R^2 \right]$

$\Delta A = 4\pi [(\Delta R)^2 + 2R\Delta R$

$\Delta A = 4\pi \times 2R\Delta R$ [$\because \Delta R^2$ is a much small quantity so it can be neglected.]

$\Delta A = \underline{\underline{8\pi R\Delta R}}$

$\therefore W = S\Delta A$

~~W =~~

$p \cdot 4\pi R^2 \Delta R = 8\pi R\Delta R \cdot S$

$p = S \cdot \frac{\overset{2}{\cancel{8}}\pi \cancel{R} \cancel{\Delta R}}{4\pi R^{\cancel{2}} \cancel{\Delta R}}$

$$\boxed{p = \frac{2S}{R}}$$

Ques: Derive the expression for exess pressure inside a Soap bubble.

$W = p \times 4\pi R^2 \times \Delta R$

$\Delta A = 2 \times 4\pi [R + \Delta R]^2 - 4\pi R^2$

$\Delta A = 2 \times 4\pi [(R + \Delta R)^2 - R^2]$

$\Delta A = 2 \times 4\pi [R^2 + (\Delta R)^2 + 2R\Delta R - R^2]$

$\Delta A = 2 \times 4\pi [(\Delta R)^2 + 2R\Delta R]$

$\Delta A = 2 \times 4\pi \times 2R\Delta R$

$\Delta A = 16\pi R\Delta R$ — (2)

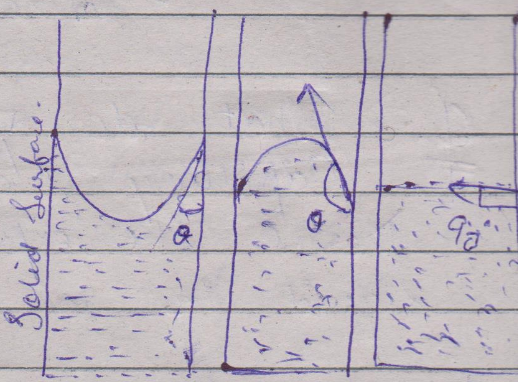
$\therefore W = S\Delta A$

$p \cdot 4\pi R^2 \Delta R = S \cdot 16\pi R\Delta R$

$p = \frac{S \cdot 16\pi R \Delta R}{4\pi R^2 \Delta R}$

$$\boxed{p = \frac{4S}{R}}$$

Q. What do you Mean by angle of Contact. Write the effects of Angle of Contact.



The Angle inside the liquid which the tangent to the liquid Surface at the point of contact Makes with the Solid Surface is called the Angle of contact for that pair of Solid and Liquid.
θ

EFFECTS OF ANGLE OF CONTACT

The Liquid Stick the Solid Surface if the angle of contact for a pair of Liquid and Solid is 90° Such as Water. Water stick with the glass. The liquid Does not stick with the Solid Surface if

⇒ the Angle of contact for that pair of Liquid and Solid > 90° Such as Mercury does not Stick with the glass.

⇒ if Angle of contact is less that 90° the Meniscus of liquid in a capillary Tube is concave and the Liquid Rises in the Capillary.

⇒ If the angle of contact is greater than 90° the Meniscus of Liquid in the Capillary Tube is convex and the Liquid fall down in the Capillary.

... Neither Rise in Capillary nor fall down: The free Capillary Surface of Liquid in Capillary is horizontal.

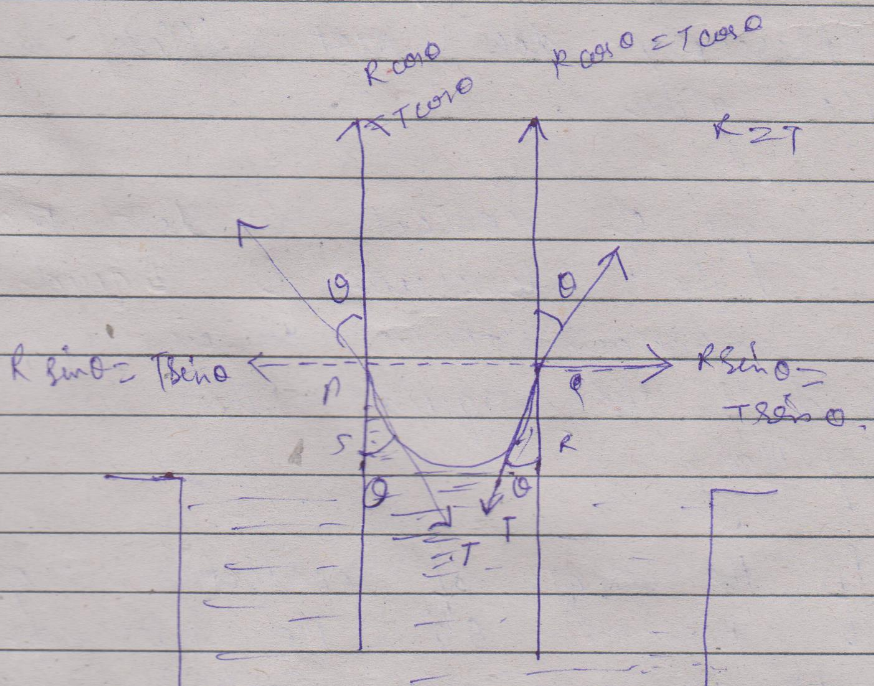
Q. What do you Mean by Capillary and Capillarity.

Derive the expression for Rise of Liquid in a capillary tube. (Ascent formula)

* **Capillary** :- A Tube with a fine and Uniform bore throughout its Length is called a capillary tube.

* **Capillarity** :- The phenomenon or rise of fall down in Liquid in a capillary tube is called capillarity.

* **Expression for rise of liquid in a capillary tube** :-



h = height to which the liquid rise ~~and~~ shown in Diag.

ρ = Density of Liquid at Room Temp

θ = Angle of contact

T = Force of Surface Tension acting Tangentially Downward to Liquid Meniscus.

R = Reaction force acting Tangentially upward to the Liquid Meniscus

but $R = T$

The Reaction force $R = T$ can be resolve into 2 Rectangular components

$R\cos\theta = T\cos\theta$ Acting upward

$R\sin\theta = T\sin\theta$ Acting $\perp$ to the Wall of the tube.

This component therefore play no part in Rising the Liquid in the tube.

Only the component Responsible for the Rising the liquid in the Tube is $T\cos\theta$.

The $T\cos\theta$ acts ~~all~~ along the circumference of the circle of contact of the liquid with the tube hence,

total upward force

~~$F = T\cos\theta$ (1)~~

$F = T\cos\theta \cdot 2\pi r$ (1)

The Vol. of Liquid in the Cylindrical Column of height h and Radius r = $\pi r^2 h$.

The vol. of Liquid under the Meniscus equal to the vol. of cylinder PQRS of height r and Radius r − volume of hemisphere.

$$\Rightarrow \pi r^2 \cdot r - \frac{2}{3}\pi r^3$$

$$\Rightarrow \pi r^3 - \frac{2}{3}\pi r^3$$

$$= \frac{3\pi r^3 - 2\pi r^3}{3}$$

$$= \frac{\pi r^3}{3}$$

Total vol. of Liquid in the capillary tube =

$$V = \pi r^2 h + \frac{\pi r^3}{3}$$

$$V = \pi r^2 \left(h + \frac{r}{3}\right)$$

Weight of Raised liquid in the tube

$$W = mg$$

$$W = V\rho g$$

$$W = \pi r^2 \left(h + \frac{r}{3}\right)\rho g \quad \text{--- (2)}$$

In equilibrium

$$F = W$$

$$T\cos\theta \cdot 2\pi r = \pi r^2 \left(h + \frac{r}{3}\right)$$

$$2\pi r \cos\theta$$

$$\boxed{T = \frac{r\left(h+\frac{r}{3}\right)\rho g}{2\cos\theta}}$$

But $h >> r/3$

⇒ So, $r/3$ can be Neglected.

⇒ ∴ $$\boxed{T = \frac{r h \rho g}{2\cos\theta}} \quad \text{— (3)}$$

⇒ For the pure water and clean glass $\theta \approx 0$

$\cos\theta = 1$

$$\boxed{T = \frac{r h \rho g}{2}} \quad \text{—}$$

$$\{\ r_1 h_1 = r_2 h_2\ \}$$

Q. What are the factor effecting the Surface Tension.

Following factor affect the Surface Tension of a Liquid :-

i) effect of Temperature :-

The Surface Tension of a Liquid increase with the Rise in Temperature

The Surface Tension of Liquid at ~~a~~ Temp. T C.

$$T_t = T_0 (1 - \alpha t)$$

T_t, T_0 are the Surface Tension at T' C and 0°C respectively and α is the Temp. cofficent of Surface Tension.

* <u>effect of Soluble impurities :-</u>

Due to the presence of Soluble impurities in a liquid. The Surface Tension either decreases or increases. If the impurities is less soluble, the Surface Tension of liquid is Increase.

EX:- On Adding soap or ~~[illegible]~~ in water. The Surface Tension of water decreases. But If the impurities is More Soluble The Surface Tension of Liquid Increase.

On dissolving Salt in water the Surface Tension of Salt Solution is more than that of pure water.

* <u>effect of insoluble impurities :-</u>

If Such a Substance is mixed in a Liquid which does not dissolve in it but that contaminated on its Surface The Surface Tension of a liquid Decrease.

Tension of water decreases.

Que: The Small drops of liquid are Spherical while large one's are flat: Why?

⇒ The Reason is that when a drop of liquid is kept on a glass plate The Shape of the Drop Depends on the Relative Magnitude of Forces

1) Force of Surface Tension due to which Surface Area of Liquid Tends to Become Minimum.

2) The force of gravity due to which the Centre of gravity tend equal to aquire the lowest position.

for a Small drop the force of gravity is Negligible in Comparison to the force of Surface Tension. Hence Drop takes the Spherical ~~Sp~~ Shape.

For a big Drop the force of gravity is Not Negligible Due to the force of Gravity the centre of gravity of the Drop tends to aquire the lowest position due to which the Drop becomes flat.

Q. Determine the Radius of New bubble form when two Bubble collage together.

Consider two bubbles of Radii r_1 and r_2 respectively. If V_1 and V_2 are the volume of two bubble then

$$V_1 = \frac{4}{3}\pi r_1^3 \text{ and}$$

$$V_2 = \frac{4}{3}\pi r_2^3.$$

Let T be the surface Tension of the solution if P_1 and P_2 are the excess pressure inside the two bubble

$$P_1 = \frac{4T_1}{r_1} \text{ and } P_2 = \frac{4T_2}{r_2}$$

Let r be the Radius of New bubble V be the volume of New bubble P be the excess of pressure inside the New bubble.

$$V = \frac{4}{3}\pi r^3 \text{ and } P = \frac{4T^2}{r}$$

Assuming the external pressure Negligible

And new bubble is formed under isothermal condition by — boyle's law

$$\Rightarrow PV = P_1V_1 + P_2V_2$$

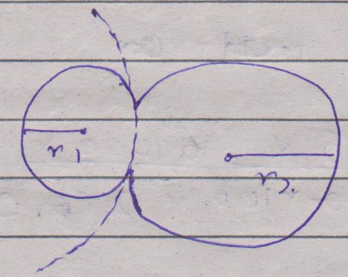
$$\frac{4\cancel{T}}{r} \times \frac{\cancel{4}}{\cancel{3}}\cancel{\pi} r^3 = \frac{4\cancel{T}}{r_1} \times \frac{\cancel{4}}{\cancel{3}}\cancel{\pi} r_1^3 + \frac{4\cancel{T}}{r_2} \times \frac{\cancel{4}}{\cancel{3}}\cancel{\pi} r_2^3$$

$$r^2 = r_1^2 + r_2^2$$

$$\boxed{r = \sqrt{r_1 + r_2}}$$

Que. Two Saop bubbles of Radii r_1 and r_2 college together to form a duble bubble. Calculate the Radius of curvature of its inner common interphase.

=> Consider two Saoap bubbles of Radii r_1 and r_2 in contact with each other as shown in fig.



Let r be the Radius of the Common boundry. If P_1 and P_2 are the excess pressure of the two sides of the interferce. Then Resultant pressure.

$$P = P_1 - P_2$$

$$\frac{4T}{r} = \frac{4T}{r_1} - \frac{4T}{r_2}$$

$$\boxed{\frac{1}{r} = \frac{1}{r_1} - \frac{1}{r_2}}$$

$$\frac{1}{r} = \frac{r_2 - r_1}{r_1 r_2}$$

$$\boxed{r = \frac{r_1 r_2}{r_2 - r_1}}$$