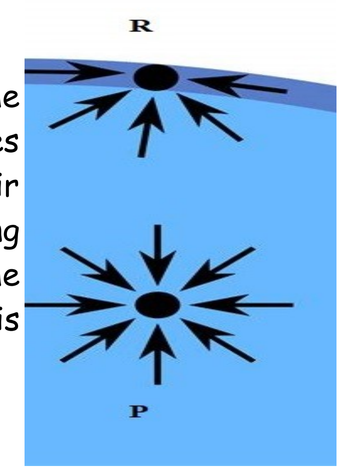
Surface Tension

Consider a molecule P some where in the body of the liquid. This is attracted equally in all directions by other molecules which surround it as shown and, therefore cancel the effect of one another.

Consider another molecule R at the surface of the liquid. The downward attractive forces are greater than the upward forces because there are more molecules of the liquid below than in the air above the surface. These unbalanced attractive forces acting downward tend to draw the surface molecules into the body of the liquid, and, therefore,tends to contract the surface of a liquid is known as surface tension.



<u>Surface tension is defined as the tangential force acting on the surface of a liquid along unit length of the surface</u>. It is represented by γ. SI unit of surface tension is Nm^{-1}.

In case of capillary tube, the surface tension can be calculated by

$$\gamma = {rh\rho g}/{2}$$

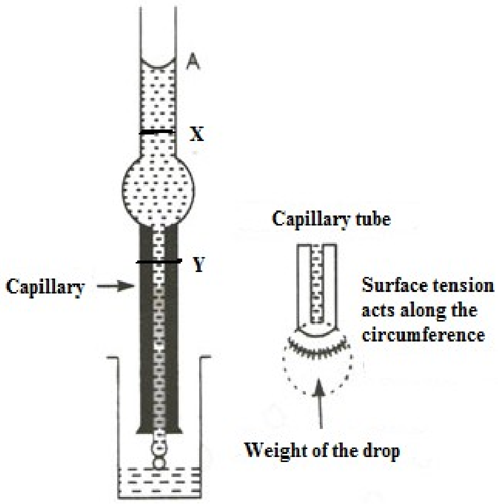
where, r is radius of capillary tube, ρ is density of liquid, g is acceleration due to gravity and h is height through which liquid raises.

Determination of surface tension of the given liquid using Stalagmometer

Procedure:

A Stalagmometer consists of a graduated capillary tube, the end of which is flattened to give a large dropping surface. Two marks, 'X' and 'Y' are above and below the bulb. A clean and dry stalagmometer is fixed vertically to a stand such that the marks are visible. A rubber tube is attached to the upper end of the instrument.

The given liquid is taken in dry beaker and sucked well above the top mark 'X' on the stalagmometer. The tap of the stalagmometer is gradually opened, allowing the liquid to flow down slowly at the rate of about 12-14 drops per minute. The number of drops of the liquid during its passage from the upper mark 'X' to the lower mark 'Y' is counted. The procedure is repeated thrice.



The stalagmometer is emptied, rinsed with alcohol or acetone and with water. The experiment is repeated for water to find the number of drops of water.

Calculations:

1. Number of drops of liquid (n_l) = ________
2. Number of drops of water (n_w) = ________
3. Laboratory temperature = ________ ℃
4. Density of liquid at the laboratory temperature (d_l) = ________ g cm^{-3}.
5. Density of water at the laboratory temperature (d_w) = ________ g cm^{-3}.
6. Surface tension of water (γ_w) = ________ dynes cm^{-1}.

Trial No.	I	II	III	Average
Number of drops of liquid (n_l)				
Number of drops of water (n_w)				

Surface tension of liquid = (γ_l) = $\frac{d_l \times n_w \times \gamma_w}{d_w \times n_l}$

= _________ dynes cm^{-1}.

= _________ $\times 10^{-3}$ N m^{-1}.

Effect of Temperature:

The surface tension of liquid decreases with rise of temperature. The surface tension of liquid is zero at its boiling point and it vanishes at critical temperature. At critical temperature, inter molecular forces for liquid and gases becomes equal and liquid can expand without any restriction. For small temperature differences, the variation in surface tension with temperature is linear and is given by the relation

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

where T_t, T_0 are the surface tensions at $t^o C$ and $0^o C$ respectively and α is the temperature coefficient of surface tension.

Examples:

i. Hot soup tastes better than the cold soup.

ii. Machinery parts get jammed in winter.

Viscosity

The flow is a characteristic viscosity of liquids. The Liquids are assumed to be made of moleculameterinNamlayers arranged one meteranother . A laminar layer has negligible thickness. The layer immediately in contact with the surface of the inner wall of the tube is stationary. When there is relative motion between two layers , there arises a frictional force or drag between the two layers which gives rise to viscosity.

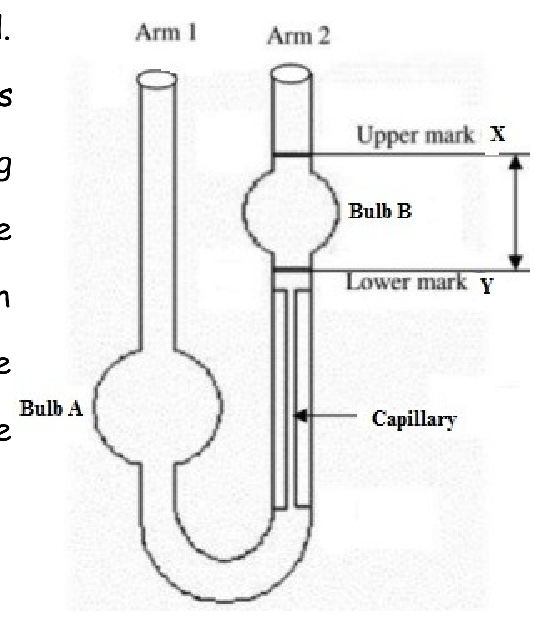
***Viscosity* may be defined as the force of friction between two layers of a liquid moving past one another with different velocities.**

***coefficient of viscosity of a liquid* may be defined as the viscous force per unit area of the layer where velocity gradient is unity.**

The coefficient of viscosity has the dimension [$ML^{-1}T^{-1}$] and its unit is Newton second per square metre (Nsm^{-2}) or kilogram per metre per second ($kgm^{-1}s^{-}$). In CGS, the unit of viscosity is Poise, 1kilogram per metre per second = 10 Poise

Determination of relative viscosity of the given liquid using Ostwald's viscometer

Procedure:



Clean and dry viscometer is fixed vertically to a stand. A known volume of the given liquid (10 - 20 cm^3) is introduced into the wider tube of the viscometer using a pipette. A rubber tube is attached to the narrow side of the viscometer and the liquid is sucked up through the capillary tube until the level of the liquid is above the mark 'X'. The liquid is allowed to flow down the capillary and a stop clock is started when the lower meniscus just passes the upper mark 'X' and stopped when it passes the lower mark 'Y'. Time of flow of the liquid is noted. The procedure is repeated thrice and mean time of flow of liquid is determined.

The viscometer is emptied, rinsed with alcohol or acetone and then with distilled water. The average time of flow of distilled water is then determined as earlier. Viscosity of water at laboratory temperature is noted.

Part 2: Determination of the relative viscosity of the liquid

1. Average time of flow of the liquid (t_l) = ________ seconds.
2. Average time of flow of the water (t_w) = ________ seconds.
3. Laboratory temperature = ________ ^0C.
4. Density of water at the laboratory temperature (d_w) = --------- g cm^{-3}.
5. Density of liquid at the laboratory temperature (d_l) = --------- g cm^{-3}
6. Viscosity of water (η_w) = --------- centipoise

Trial No.	1	2	3	Average
Time of flow of liquid in seconds (t_l)				
Time of flow of liquid in seconds (t_w)				

Viscosity if liquid (η_l) = $\dfrac{d_l \times t_l \times \eta_w}{d_w \times t_w}$

=

= ___________ $\times 10^{-3}$ Nsm^{-2}.

Effect of Temperature:

The viscosity of a liquid generally decreases with rise in temperature. The decrease is appreciable , being about 2 % per degree rise of temperature. The relationship between coefficient of viscosity of a liquid and temperature is expressed as

$$\eta = A\exp(Ea/RT)$$

where A and E are constants for a given liquid. E_a is called Activation energy for viscous flow.

Note:

In contrast η increases with increasing temperature in the case of gases