Experiment No.:   **Date:**

Aim: To determine the viscosity of a given unknown liquid with respect to water, at laboratory temperature, by viscometer.

Requirements: Ostwald viscometer, rubber tube with screw pinch cock, relative density (R.D) bottle (known as pyknometer also), stand, beaker, unknown liquid, distilled water.

Theory: The force of friction which one part of the liquid offers to another part of the liquid is called viscosity. For measuring the viscosity coefficient, Ostwald viscometer method is used which is based on Poiseuille's law. According to this law, the rate of flow of liquid through a capillary tube having viscosity coefficient, η, can be expressed as

$$\eta = \frac{\pi \cdot r^4 tP}{8vl}$$

where, v= vol. of liquid (in ml)

         t= flow time (in sec.) through capillary

         r= radius of the capillary (in cm)

         l= length of the capillary (in cm)

         P= hydrostatic pressure (in dyne/sq.cm)

η= viscosity coefficient (in poise).

Since, the hydrostatic pressure (the driving force) of the liquid is given by P = dg h (where h is the height of the column and d is the density of the liquid);

              η ∝ P t ;   or,   η ∝ d g h t

If, η_1 and η_2 are the viscosity coefficients of the liquids under study, d_1, d_2 , are their densities and t_1 and t_2 are their times of flow of *equal volume* of liquids through the same capillary respectively, then

              η_1 ∝ d_1 g h t_1 and η_2 ∝ d_2 g h t_2

Hence, $\dfrac{\eta_1}{\eta_2} = \dfrac{d_1 t_1}{d_2 t_2}$

Here, usually the viscosity of given liquid is measured with respect to water whose viscosity is known very accurately at different temperatures. The SI physical unit of viscosity is the pascal-second (**Pa·s**), (i.e., $kg \cdot m^{-1} \cdot s^{-1}$). This means: if a fluid with a

viscosity of one **Pa·s** is placed between two plates, and one plate is pushed sideways with a shear stress of one pascal, it moves a distance equal to the thickness of the layer between the plates in one second. The cgs unit for the same is the **poise** (P), (named after J. L. Marie Poiseuille). It is more commonly expressed, as **centipoise (cP)**. [1 cP = 0.001 Pa·s]. Water at 20 °C has a viscosity of 1.0020 cP.

Procedure:

1. Note the laboratory temperature.

2. Wash the R.D.bottle with distilled water and dry.

3. Take the weight of the empty & filled (with distilled water) R.D. bottle (with stopper). Then, weigh the R.D. bottle filled with unknown given liquid. Use the data for measuring the densities.

4. Clean and rinse the viscometer properly with distilled water. Fix the viscometer vertically on the stand and filled with specific amount (say 20ml) of mixture (every time take the same volume).

5. Time of flows were recorded for each solutions (water and the given liquid).

 6. Take 3 to 4 readings.

Observations:

1. Laboratory temperature=…. ˚C

2. Density measurement:

Weight of empty R.D.bottle (w_1) =…g.

Weight of R.D.bottle with water (w_2) =…g.

Weight of R.D. bottle with liquid (w_3) =…g.

So, weight of water (w_w) = (w_2-w_1) =…g.

$$\text{Relative density} = \frac{\left(\dfrac{\text{Mass}}{\text{Vol}}\right)_{liq}}{\left(\dfrac{\text{Mass}}{\text{Vol}}\right)_{water}} = \frac{(\text{Mass})_{liq}}{(\text{Mass})_{water}} \quad \text{(since, volume is same for all)}$$

3. Combined table for the measurement of flow times and relative densities:

Sl no.	Flow times (sec)			
	t_1	t_2	t_3	mean
1				
2				
3				
4				

Calculations:
1. Determination of the density of the liquid (d_l):

$$\frac{\text{Density of liquid } (d_l)}{\text{Density of water } (d_w)} = \frac{\text{Weight of liquid } (w_l)}{\text{Weight of water } (w_w)}$$

$$\text{Density of liquid } (d_l) = \frac{w_l}{w_w} d_w \quad \text{(Take density of water} = 1.0 \text{g/ml at 25 }^\circ\text{C)}$$

2. Determination of the viscosity of the liquid (η_l)

$$\text{Viscosity of the liquid, } \eta_l = \frac{t_l d_l}{t_w d_w} \eta_w$$

Result: The viscosity of the given liquid with respect to water at laboratory

temperature was found to be ……..cP.

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Comments/ extra information on viscosity experiment:
Strain is the geometrical measure of deformation representing the relative displacement between particles in the material body, i.e. a measure of how much a given displacement differs locally from a rigid-body displacement.

Stress is a measure of the average amount of force exerted per unit area. It is a measure of the intensity of the total internal forces acting within a body across imaginary internal surfaces, as a reaction to external applied forces and body forces.

A **Newtonian fluid** (named for Isaac Newton) is a fluid whose stress versus rate of strain curve is linear and passes through the origin. The constant of proportionality is known as the viscosity.

For example, water is Newtonian, because it continues to exemplify fluid properties no matter how fast it is stirred or mixed. Contrast this with a non-Newtonian fluid, in which stirring can leave a "hole" behind (that gradually fills up over time - this behaviour is seen in materials such as pudding, starch in water or cause the fluid to become thinner, the drop in viscosity causing it to flow more (this is seen in non-drip paints, which brush on easily but become more viscous when on walls).

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