التجربة الثالثة

اسم التجربة:- اللزوجة السائل

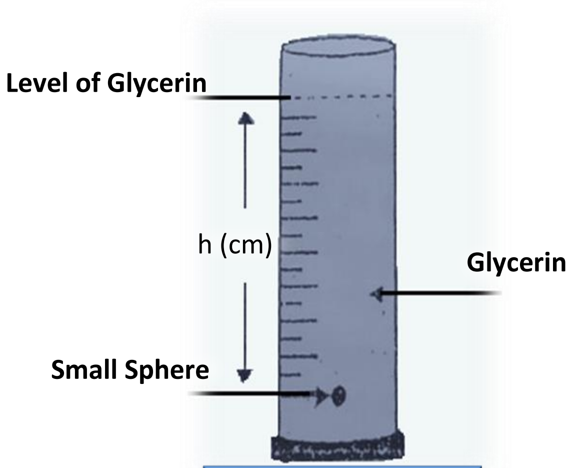
Viscosity of liquid

The purpose of the experiment:-

Determine the viscosity coefficient of the liquid.

Used equipment's :-

1. A long glass tube about (50 cm) long closed at one end.
2. Glycerin..
3. Meter scale.
4. Small sphere.
5. Rubber bands.
6. Magnet.
7. Stop-Watch.



Glass Cylinder

Theory :-

If we pour an amount of water, an amount of oil, and another amount of glycerin, we notice a difference in the ability of each of the three liquids to move and flow, as we find that the water responds easily to the effect of the force that moves it, compared to the movement of oil and glycerin, which responds with difficulty and is slow to flow.

The property that distinguishes a liquid in terms of its response to movement (its degree of flow) is called viscosity.

Which results from the presence of something like internal friction between the layers of the liquid or between the molecules of the liquid, and the greater the value of this friction, the greater the viscosity of the liquid. This friction results in a force that resists the movement of the liquid, which limits its ability to flow and flow freely.

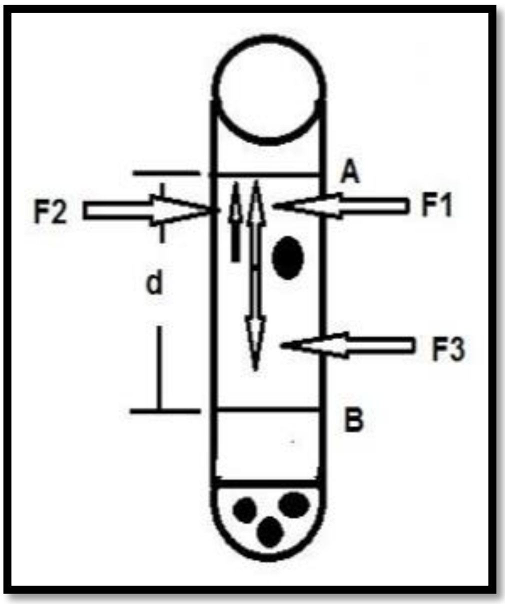
Therefore, viscosity can be defined as The resistance shown by the layers of a liquid to movement between its layers and between its layers and a solid body in which it moves. Thus, what is meant by viscosity is the property of the medium that is characterized by the action of internal frictional forces in it during the movement of parts of this medium.

The movement of the medium is called stable movement or laminar movement if the speed of flow at each of its points does not change with the passage of time.

The liquid is fully described through the following three parts:
A part adjacent to the wall of the vessel, a part adjacent to the wall of the vessel, and an internal part.

There is no doubt that the speed of the liquid molecules adjacent to the wall of the container is less than the speed of the molecules of the neighboring layers, due to the force of adhesion between the liquid molecules and the walls of the container that it contains.

When a metal ball is dropped into a viscous liquid (such as glycerin), the layer of liquid will stick to the ball and move downward with it, while the other layers of the liquid resist that movement due to the cohesive forces between the liquid molecules until the ball eventually reaches a uniform speed and balances under the influence of the force. Shown as follows



The figure above shows the acting force, which is:

1- The force of the viscosity of the fluid, upward (F_1 ↑):
According to Stock's law, the ball with radius (r) falling in a fluid of viscosity (η) and with a uniform final speed opposes its movement and upward, the force of the viscosity of the fluid, which is equal to: $\uparrow F_1 = 6\pi r v \eta$ ……… (1)

2- Buoyant force (F_2↑) (the weight of the displaced fluid):
It also tends upward, as shown in the figure above, and its amount is equal to: $\uparrow F_2 = \frac{4}{3}\pi r^3 \sigma g$ ……… (2)

3- The weight of the ball used downward (F_3↓), which is the downward pulling force that the ball is exposed to inside the fluid due to gravity, and is equal to: $\downarrow F_3 = \frac{4}{3}\pi r^3 \rho\, g$ …… (3)

Whereas:-

$(\eta) \equiv$ Fluid viscosity coefficient, $(v) \equiv$ Ball velocity, (r) ≡ The radius
(g) ≡ Ground acceleration, $(\sigma) \equiv$ Liquid density, $(\rho) \equiv$ Ball density

The viscosity force combined with the weight of the displaced fluid is equivalent to the weight of the ball used : $(F_1 + F_2 = F_3)$

By substituting and solving the equations, the viscosity coefficient can be calculated:

$$6\pi r v \eta + \frac{4}{3}\pi r^3 \sigma g = \frac{4}{3}\pi r^3 \rho\, g \quad \dots\dots\dots (4)$$

$$\eta = \frac{4r^2 g(\rho - \sigma)}{18 * v} \quad \dots\dots\dots \ (5)$$

Substituting the value of the radius (r) in terms of the diameter (d)

$$\boldsymbol{\eta = \frac{g(\rho - \sigma).\, d^2}{18 * v}} \quad \dots\dots\dots \quad \mathbf{(6)}$$

The viscosity of fluids is affected by many factors, including:

1- **Temperature**: Viscosity decreases with an increase in temperature because increasing the temperature increases the movement of molecules, so the forces of attraction between the molecules decrease relatively. If the attraction decreases, the viscosity decreases.
2- **The presence of dissolved substances**: Dissolved substances in the liquid affect the viscosity. For example, the presence of sugar in water increases the viscosity of the water, while the presence of ionic salts in the water reduces the viscosity of the water. The presence of suspended materials in the liquid increases its viscosity. For example, blood is more viscous than water due to the presence of proteins and platelets suspended in it.
3- **Pressure**: By increasing the pressure on the liquid, the attractive forces between the liquid molecules increase, and thus the viscosity increases somewhat.

Work steps :-

1- Measuring the diameters of balls is used
2- Dropping the ball into the viscous liquid, taking into account that the drop location is in the middle of the liquid so that the ball moves freely, while calculating the fall time for the specified height.
3- Calculate the speed x by dividing the distance d by the time T using the graph.
4- Calculate the viscosity coefficient using the relationship(6)

$$\eta = \frac{g(\rho - \sigma).d^2}{18 * v} \quad \dots\dots\dots \quad (6)$$

Distance between the rubber bands h (cm)	Time of fall		
	T1 (Sec)	**T2** (Sec)	T_{av} (Sec)

$$\text{Slope} = \frac{\Delta h}{\Delta T}$$