EXPERIMENT.2

VISCOSITY COEFFICIENT OF GLYCERIN

Goal: Measuring the viscosity coefficient of any liquid by Stoke's Law.

Theory:

Stoke's Law: If viscous liquid flows around a globe or a globe moves in a still viscous liquid, a friction force acts on the globe. We will call this friction force. Because of the viscosity of liquid, the globe moves with a constant speed, V.

According to Stoke's Law, flow speed V is in direct proportion to the friction force F_V and inversely proportional to radius of globe r.

$$F_V = 6\pi\eta Vr$$

where η is viscosity coefficient.

Now we consider a viscous liquid with a falling globe inside. If initial speed of globe is zero then the friction force is also zero at the beginning. There are only gravity and ascending force acting on the globe.

- Gravity: $mg = \frac{4}{3}\pi r^3 \rho_2 g$
- Ascending Force: $F_a = \frac{4}{3}\pi r^3 \rho_1 g$

where ρ_1 is mass density of liquid and ρ_2 is mass density of globe. According to the Newton's Second Law, we find the initial acceleration of globe.

- Net Force: $ma = mg - F_a$

$$\therefore a = \frac{\rho_2 - \rho_1}{\rho_2} g$$

In addition to gain velocity due to this acceleration, the globe is acted by an additional force which is expressed by Stoke's Law. This additional force is nothing but the friction force F_V which is mentioned above. Since speed increases, the friction force increases proportionally. Finally, globe gains a limit speed which gives a friction force equal to the net force acting on the globe. After that, the acceleration wanishes and the globe moves with a constant speed which is called as “final speed”. We may find this speed by making the net force equal to the friction force.

$$ma = mg - F_a = F_V$$

$$\therefore \eta = \frac{2}{9}\frac{\rho_2 - \rho_1}{V} g r^2$$

where η is viscosity coefficient of liquid and V is the thermal speed of the globe.

Apparatus:

1. Glycerin
2. 100ml graduated cylinder
3. Thermometer
4. 5 steal balls in different radius
5. Stopwatch

Experimental Setup:

1. Fill the graduated cylinder with glycerin. Wait for the bubbles wanish.
2. Clean the balls from grease and oil by sopping in sodium hydroxide. (After that hold the balls with tweezers!)
3. Measure the diameters of balls with your micrometer and calculate each radius. Write your results in Table 1.
4. Mark the specified levels A and B where balls fall with constant speed.
5. Let balls go one by one from the surface of glycerin. Keep the falling time from A to B. (three times for each ball)
6. Use your thermometer to take the temperature of glycerin.

Calculations and Analyses:

Quantities:

- Mass density of steal ball: $\rho_2 = 7870\, kg/m^3$
- Mass density of glycerin: $\rho_1 = 900\, kg/m^3$
- Gravitational acceleration: $g = 9{,}80\ m/s^2$

- Lenght of A-B: $L =$ ________________ m
- Temperature of glycerin: $T =$ ________________ ^0C

Table 1:

Falling Time, $t\ (s)$				Thermal Speed, $V\ (m/s)$	Steal Balls		$r^2\ (cm)$	Viscosity Coefficients $\eta\ (N/s)$
t_1	t_2	t_3	t_{avr}		Diameter, $d\ (cm)$	Radius, $r\ (cm)$		
							$\eta_{avr} =$	

1. Calculate the thermal speeds and write these down into related columb of Table 1
2. Calculate the viscosity coefficients $\eta_1, \eta_2, \eta_3, \dots$ etc. and get the aritmetic mean of these quantities.
3. Draw the $V - r^2$ graph according to Table 1 and calculate the slop of the graph.
4. Calculate the viscosity coefficient of glycerin at the temperature T with this formula

   $$\eta_{graph}(T\ ^0C) = 2g\frac{\rho_2 - \rho_1}{g \times (slope)}$$

5. Calculate the viscosity coefficient of glyserin at $18\ ^0C$

   $$\eta(18\ ^0C) = \eta(T\ ^0C)[1 + 0{,}026(T - 18)]$$

6. Compare your results with the accepted values in other literatures.

Error Calculation:

1. Calculate your percentage error for η.
2. Derive the relative error formula from $\eta(18\ ^0C)$.
3. Calculate the maximum absolute error for each measure.
4. Calculate the average standart deviation with η
5. Itemize the possible causes of error.

Results and Comments:

Write down your results and interpret your conclusions in accordance with your information you gain in this experiment

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