

## 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  $\eta$  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  $\rho_1$  is mass density of liquid and  $\rho_2$  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 vanishes 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.

$$ma = mg - F_a = F_v$$

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

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

- Length of A-B:  $L = \text{_____} m$
- Temperature of glycerin:  $T = \text{_____} ^\circ C$

**Table 1:**

Falling Time, $t$ (s)				Thermal Speed, $V$ (m/s)	Steel 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 column of Table 1
2. Calculate the viscosity coefficients  $\eta_1, \eta_2, \eta_3, \dots$  etc. and get the arithmetic mean of these quantities.
3. Draw the  $V - r^2$  graph according to Table 1 and calculate the slope of the graph.
4. Calculate the viscosity coefficient of glycerin at the temperature  $T$  with this formula

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

5. Calculate the viscosity coefficient of glycerin at  $18 ^\circ C$

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

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

**Error Calculation:**

1. Calculate your percentage error for  $\eta$ .
2. Derive the relative error formula from  $\eta(18 ^\circ C)$ .
3. Calculate the maximum absolute error for each measure.
4. Calculate the average standard deviation with  $\eta$
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

## EXPERIMENT 2. VISCOSITY COEFFICIENT OF GLYCERIN

[illegible]