Aim

To determine the viscosity coefficient and composition of a given acetic acid solution by viscometer.

Theory

Viscosity is friction effect. The internal friction or resistance between layers of liquid, which resist the relative motion of each part i.e. the flow of the liquid is known as viscosity.

The rate of laminar flow of a liquid through a capillary tube at constant pressure is related to the coefficient of viscosity η (eta) of the liquid and is given by Poisseuille's equation

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

Where, P is the constant pressure difference at two ends of the tube

r is radius of the tube

t is time of flow of the liquid through the tube

v is volume of the liquid

l is length of the tube

The pressure 'P' at any instant 't' is given by $P = h\rho g$

Where 'h' is the difference of the levels of the liquid in the two limbs of the tube.

'ρ' is the density of liquid.

'g' is acceleration due to gravity.

Therefore, we have

$$\eta = \frac{\pi r^4 t(h\rho g)}{8vl} \quad \text{or} \quad t = \frac{8vl\eta}{\pi r^4 t(h\rho g)}$$

$$\text{or,} \quad t \;\alpha\; \frac{\eta}{h\rho g}$$

i.e. the time of flow of liquid is directly proportional to the viscosity and inversely proportional to the driving force.

For a liquid of density 'ρ' having coefficient of viscosity 'η_1', the time of flow 't_1' is given by

$$t_1 \;\alpha\; \frac{\eta_1}{h\rho_1 g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

If 't_2' is the time of flow of another liquid for the same volume, then

$t_2 \; \alpha \; \frac{\eta_2}{h\rho_2 g}$ ……………………..(2)

Now, from equation (1) and (2), we have

$$\frac{t_1}{t_2} = \frac{\eta_1\rho_2}{\eta_2\rho_1}$$

$$\frac{\eta_1}{\eta_2} = \frac{\rho_1 t_1}{\rho_2 t_1}$$

Thus, knowing the value of t_1, t_2, ρ_1, ρ_2 and η_2, the value of 'η_1' can be calculated.

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 $m^{-1}s^{-1}$). 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.

Requirements:

1) Ostwald's viscometer

2) Pyknometer

3) Acetic acid solutions

4) Burette stand

5) Stop-watch

Procedure:

1) The viscometer is thoroughly cleaned, 20ml of distilled water was pipetted out and water was sucked out till the liquid was drawn above the mark of the arm.

2) The liquid was allowed to flow down and the time taken for the liquid to pass from the top to the bottom mark of the capillary arm was noted with the help of a stop-watch.

3) The procedure was repeated with 5%, 10%, 15%, 20%, and the unknown acetic acid solution and the respective times were noted down.

4) The weight of the empty pyknometer (w_1) was taken.

5) The pyknometer was then filled with distilled water and its weight (w_2) was taken.

6) The pyknometer was then filled with the prepared glycerol solution and their weights (w_3) were also recorded.

7) Specific gravity of each solution was also calculated by using the relation,

Observation:

Observation:

1) Room temperature = 20^0C

2) η of water at 20^0C = 1.0020 cP

3) Specific gravity : $\rho_1/\rho_2 = (w_3-w_1)/(w_2-w_1)$

Where w_1 → weight of empty pyknometer

w_2 → weight of pyknometer+water

w_3 → weight of pyknometer+ Acetic acid solution

Table 1: Determination of specific gravity

Particulars	**Water**	**Acetic acid solution concentration**				
		5 %	**10 %**	**15 %**	**20 %**	**Unknown**
Weight of pyknometer+liquid	w_2	w_3	w_3	w_3	w_3	w_3
Weight of liquid	w_2-w_1	w_3-w_1	w_3-w_1	w_3-w_1	w_3-w_1	w_3-w_1
Specific gravity $\frac{\rho_1}{\rho_2} = \frac{w_3-w_1}{w_2-w_1}$	----					

Table 2: Determination of coefficient of viscosity

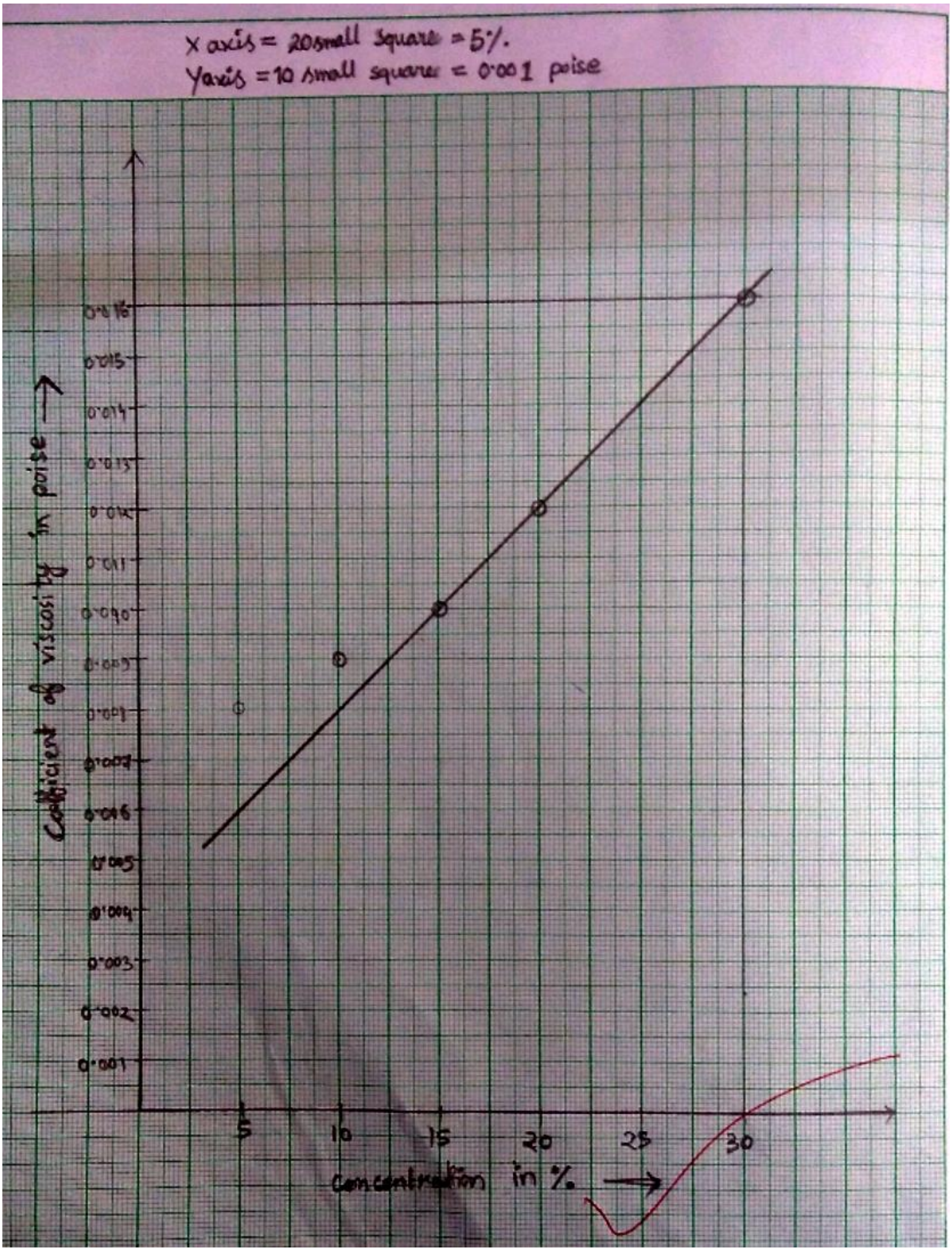
Sl. No.	Liquids	Time (t) sec			Specific gravity, ρ_1/ρ_2	Coefficient of viscosity, (cP) $\frac{\eta_1}{\eta_2} = \frac{\rho_1 t_1}{\rho_2 t_1}$
		1st	2nd	Mean		
1	Water				------	1.0020
2	5% solution					
3	10% solution					
4	15% solution					
5	20% solution					
6	unknown					

Plotting of graph: A graph is plotted by taking concentration of the solution along x-axis and coefficient of viscosity along y-axis.

A straight line is obtained.

Result

The concentration of the unknown solution is _______ %


X axis = 20 small square = 5%.
Y axis = 10 small squares = 0·001 poise
Coefficient of viscosity in poise →
0·016
0·015
0·014
0·013
0·012
0·011
0·010
0·009
0·008
0·007
0·006
0·005
0·004
0·003
0·002
0·001
5
10
15
20
25
30
Concentration in % →