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Milikan's Oil drop experiment

Aim:

Calculation of electric charge on an oil drop and to show that electric charge exists as multiples of the charge e of an electron.

Apparatus:

Milikan's Oil drop ~~experiment~~ apparatus, oil, power supply and stopwatch

Formula used :

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Calculations:

Formulas used:

$$F = 6\pi\eta r v$$

$$g = 9.80665\ m/s^2$$

$$6\pi\eta r v_1 = (m_{oil} - m_{air})g$$

$$6\pi\eta r v_1 = V(\rho_o - \rho_a)g$$

$$6\pi\eta r v_1 = \frac{4}{3}\pi r^3(\rho_o - \rho_a)g \quad \text{— (1)}$$

$$r = \sqrt{\frac{9 v_1 \eta}{2 g \rho}}$$

$$QE = V(\rho_o - \rho_a)g$$

$$QE = \frac{4}{3}\pi r^3(\rho_o - \rho_a)g \quad \text{— (2)}$$

from eq (1) and (2), determine the charge (Q) on the drop

$$\frac{QU}{d} = \frac{4}{3}\pi\left(\frac{9 v_1 \eta}{2 g \rho}\right)^{3/2} \rho g$$

$$Q = v_1^{3/2}\eta^{3/2}\frac{18\pi d}{U\sqrt{2\rho g}} \quad \text{— (3)}$$

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$$Q'E = 6\pi\eta r v_2 + v(\rho_0 - \rho_a)g$$

$$Q'\frac{U}{d} = 6\pi\eta r v_2 + \frac{4}{3}\pi r^3(\rho_0 - \rho_a)g \quad (4)$$

combine equation (1) and (4) and solving for Q results in

$$Q' = (v_1 + v_2)\frac{\sqrt{v_1}}{U}\eta^{3/2}\frac{18\pi d}{\sqrt{2g\rho}}$$

Calculations: (done in observation table)

Distance b/w the plates (d) = 0.016 m

olive oil density (ρ_0): 920 Kg/m^3

Air density (ρ_a): 1.225 Kg/m^3

electric charge on a single $e^\ominus$ (q) = $1.60217657 \times 10^{-19}$ C

Viscosity of air (η) = 1.81×10^{-5} NS/m^2

gravitational acceleration (g) = 9.80655 m/s^2

constant (π) = 3.14159

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Conclusion

The electric charges on the droplets are approximately integral multiples of electric charge of a single electron.

for olive oil

No. of oil drop	Distance travelled downward l_1(m)	Time taken for downward travel t_1(sec)	Distance travelled upward l_2(m)	Time taken for upward travel t_2(sec)	Terminal velocity (m/sec) $v_1 = \frac{l_1}{t_1}$	$v_2 = \frac{l_2}{t_2}$	Balancing potential (V)	Charge of the drop Q(C)	Charge of the drop Q'(C)
1	0.0025	1.07	0.0025	2.27	0.23×10^{-2}	0.11×10^{-2}	2900	6340.32×10^{-19}	$9706.[illegible] \times10^{-19}$
2	0.0025	5.47	0.0025	6.16	4.57×10^{-4}	4.05×10^{-4}	1200	1502.2×10^{-19}	1629×10^{-19}
3	0.0025	0.31	0.0025	1.39	0.8×10^{-2}	0.12×10^{-4}	5400	21966.466×10^{-19}	22621×10^{-19}
4	0.0025	0.58	0.0025	0.63	0.4×10^{-2}	6.42×10^{-4}	1100	4215.55×10^{-19}	8818×10^{-19}
5	0.0025	3.39	0.0025	3.44	7.37×10^{-4}	7.26×10^{-4}	1800	67.82×10^{-19}	135.557×10^{-19}

No. of oil drop	Ratio, $\frac{Q}{q}$	Nearest integer	percentage error	Average % error	Ratio $\frac{Q'}{q}$	Nearest integer	% error	Avg. % error
1	3962.7	396.3	0.0075		6066.386	6066	0.0063	
2	938.87	939	0.013	0.185%	1018.355	1018	0.034	0.202%
3	15729.037	13729	0.0026		14188.71	14139	0.0020	
4	2633.46	2633	0.017		5511.39	5511	0.007	
5	42.38	42	0.89		84.71	85	0.34	