Expt. No. 9

Date

Page No.

Millikan's Oil drop Experiment

Aim →

* Calculation of electric charge on an oil drop and show that electric charge exists.

Apparatus →

* Millikan's oil drop apparatus, oil, power supply.

Formula Used →

① $\boxed{F = 6\pi\eta r v}$

here η is viscosity
v is velocity
F is viscous force

② $$6\pi\eta r v_1 = v(\rho_o - \rho_a)g$$

$$6\pi\eta v r_1 = \frac{4}{3}\pi r^3(\rho_o - \rho_1)g$$

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

Teacher's Signature :

Date

Expt. No.   Page No.

③ $QE = \frac{4}{3} \pi r^3 (\rho_0 - \rho_a) g]$

④ $Q = v_1^{3/2} \eta^{3/2} \frac{18\pi d}{\sqrt{2\rho g} \times U}$

Observation and Calulation →

① Calculated the electric charges on the oil drop using eqⁿ ③, the charges should be integer multiple of single electron charge.

② Calculated ~~Find~~ the ratio (Q/q) and round them up to the nearest Integer. Also calculated the % error of the ratios.

Teacher's Signature :

No. of oil drop	Distance Travelled Downward, l_1 (m.)	Time taken for downward travel, t_1 (sec.)	Terminal velocity, v_1 $(\frac{l_1}{t_1})$ (m/sec)	Balancing Potential, U (volt)	Charge of the drop, (from Eq.3) Q (C)	Ratio, $\frac{Q}{q}$	Nearest Integer	Percentage of error	Average percentage error
1	0.0025	9.895	2.5265×10^{-4}	0.3×10^{3}	6.9476×10^{-18}	43.3635	43	0.8453%	0.8733%
2	0.0025	4.588	5.4489×10^{-4}	1.2×10^{3}	5.5012×10^{-18}	34.3357	34	0.9873%	
3	0.0025	2.365	1.0570×10^{-3}	2.6×10^{3}	6.8599×10^{-18}	42.8161	43	0.4276%	
4	0.0025	1.559	1.6035×10^{-3}	5.4×10^{3}	6.1714×10^{-18}	38.5188	39	1.233%	

Expt. No. ____ Date ____ Page No. ____

Calculations →

Formula →

$$Q = (V)^{3/2} \cdot (1.81 \cdot 10^{-5})^{3/2} \cdot 18 \cdot \pi \cdot \frac{0.016}{U \cdot \sqrt{2 \times 918.775 \times 9.80665}}$$

where,

$Q \rightarrow$ Charge of the drop

$V \rightarrow$ Terminal velocity $\boxed{V = l_1/t_1}$

$U \rightarrow$ Balancing Potential

$l_1 \rightarrow$ Distance travelled downwards

$t_1 \rightarrow$ time taken for downward travel.

For drop 1 →

$$V = \frac{0.0025}{9.895} = 2.5265 \times 10^{-4} \text{ m/sec}$$

$U = 0.3 \times 10^3$ Volt

$Q = 6.9476 \times 10^{-18}$ C (Using above formula)

$Q/q = 43.3635$

For drop 2 →

$$V = \frac{0.0025}{4.588} = 5.4489 \times 10^{-4} \text{ m/s}$$

$U = 1.2 \times 10^3$ Volt

$Q = 5.5012 \times 10^{-18}$ Coulomb

$Q/q = 34.3357$

Teacher's Signature : ____

Date

Expt. No.   Page No.

For drop 3 →

$$v = \frac{0.0025}{2.365} = 1.0570 \times 10^{-3} \text{ m/sec}$$

$$V = 2.6 \times 10^{3} \text{ Volt}$$

$$Q = 6.8599 \times 10^{-18} \text{ Coulomb}$$

$$Q/q = 42.8161$$

For drop 4 →

$$v = \frac{0.0025}{1.559} = 1.6035 \times 10^{-3} \text{ m/sec}$$

$$V = 5.4 \times 10^{3} \text{ Volt}$$

$$Q = 6.1714 \times 10^{-18} \text{ Coulomb}$$

$$Q/q = 38.5188$$

Conclusion →

* The electric charge on droplets should be integer multiple of electric charge of a single electron.

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Calculations →

For drop 1 →

$$\% \text{ error} = \frac{\cancel{|29.4|}\ |43.3635 - 43|}{43} \times 100$$

$$= 0.8453\%$$

For drop 2 →

$$\% \text{ error} = \frac{|34.3357 - 34|}{34} \times 100$$

$$= 0.9873\%$$

For drop 3 →

$$\% \text{ error} = \frac{|42.8161 - 43|}{43} \times 100$$

$$= \cancel{0.54084\%}\ 0.4276\%$$

For drop 4 →

$$\% \text{ error} = \frac{|38.5188 - 39|}{39} \times 100$$

$$= 1.233\%$$