R02.2

Millikan's Oil Drop Experiment

Demonstration experiment

Millikan's experiment was that first used to determine the magnitude of the charge the electron. Charged oil drops are placed in a capacitor and subjected to an electric field, and also to the force of gravity, and their terminal velocity is recorded. Their velocity is recorded with the field both opposing and augmenting gravity, and from this the charge on the drop can be determined.

Introduces:
Specific electronic charge

Item	Quantity	Code	Price
Millikan's apparatus	1	P72-5000	£217.50

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What to do:

1. The apparatus comes with complete instructions on how to use it to obtain the velocities.
2. Using Stoke's law, the force experienced by the drop moving through the air with velocity v is $F = 6\pi\eta vr$, where η=viscosity of air, r= radius of droplet.
3. Force of gravity $F = mg = \rho(o)Vg$, where m=mass of droplet, V=volume of droplet, and ρ(o) is the density of the oil
4. Force of buoyancy $F = \rho(a)Vg$, where ρ(a) is the density of air
5. Electrical force $F = QU/d$, where Q=charge on droplet, and U=capacitor voltage
6. At the terminal velocity, the sum of the forces is zero, hence when this velocity has been reached,

   $$0 = -6\pi\eta v_1 r + QU/d + \frac{4}{3}\pi r^3(\rho(o) - \rho(a))$$ with the electric field complimenting gravity, and

   $$0 = -6\pi\eta v_2 r + QU/d - \frac{4}{3}\pi r^3(\rho(o) - \rho(a))$$ with the electric field opposing gravity
7. Combining these, and making Q the subject of the formula:

   $$Q = \frac{9}{2}\pi d \cdot \sqrt{\frac{\eta^3}{g(\rho(o) - \rho(a))}} \cdot \frac{(v_1 + v_2)}{U} \cdot \sqrt{(v_1 - v_2)} = 2.73 \cdot 10^{-11} \frac{(v_1 + v_2)}{U} \cdot \sqrt{(v_1 - v_2)} \text{ C}$$
8. Calculation of this charge always yields integer multiples of 1.6x10-19 C, showing this to be the unit of electric charge.