Date- 28.04.20

SUBJECT - CHEMISTRY

CLASS - BSc (Sub./Gen.) PART-I

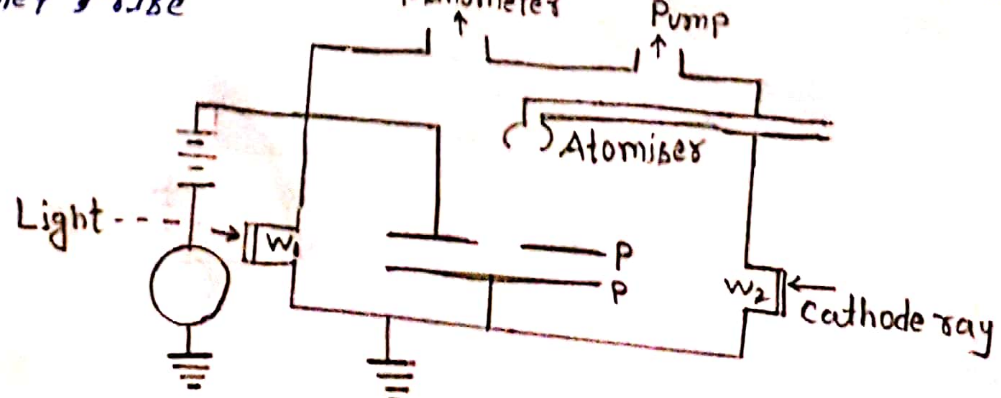
GROUP - B

TOPIC - MILIKAN's OIL DROP EXPERIMENT

Dr Hari Mohan prasad Singh
Department of Chemistry
Dr. L.K.V.D College Tajpur Samastipur

Q Describe briefly Milikan's oil drop experiment for the determination of the charge on an electron. Give its value.

Ans The magnitude of electronic charge is measured by Milikan's oil drop experiment (1898). Tiny oil droplets are sprayed by an atomiser into a chamber. The chamber is kept in a thermostat. It is filled with air at very low pressure. There are two parallel plates PP In the chamber, the upper one has some inlets and is connected to high voltage battery and the lower electrode is earthed. As soon as the droplet passes through the inlet, the inlet gets closed. the air space between the electrodes is then ionised by passing X-rays through the window W_2. The droplet attaches itself to a gaseous ion and becomes charged. The light coming from an arc lamp Through window W_1 illuminates the oil droplet so that its movement can be viewed through a telescope. The time t_1 taken by the drop to fall under the gravity alone is noted. An electrostatic potential is then applied so as to make the droplet rise



upward against the gravitational force in an electric field of strength E and the time t_2 taken by the drop to travel the same distance (x) is noted again. The battery is short circuited and the time taken by the drop to fall under gravity is noted again. If v_1 and v_2 be be the rate of fall and rise of the droplet respectively, then

$$\frac{v_1}{v_2} = \frac{x/t_1}{x/t_2} \Rightarrow \frac{v_1}{v_2} = \frac{t_2}{t_1}$$

And therefore $\frac{t_2}{t_1} = \frac{mg}{Ee - mg}$

or $\frac{t_2}{t_1 + t_2} = \frac{mg}{Ee}$ or $e = \frac{mg}{E} \cdot \frac{t_1 + t_2}{t_2}$ -- (1)

where m is the mass of the drop and e is the charge on it from Stoke's law, m is taken to be $4/3 \pi r^3 \rho$ because oil droplet is almost spherical and hence from foregoing facts, we have

$$e = \frac{4/3 \pi r^3 \rho g}{E} \cdot \frac{t_1 + t_2}{t_2} \quad \ldots (2)$$

All the terms in (2) being known e can easily be calculated By varying E, Milikan experiment shows that e is a simple multiple of 1.6091×10^{-19} coulombs. This is therefore taken as the absolute charge of the single electron.

(a) when a beam of X-ray is allowed to pass through the window into the air space between the parallel plates the air gets ionised and the oil droplet attaches itself to a gaseous ion and gets charged. They are also charged by friction.

(b) The charged carried by oil droplets is positive and negative both.

(c) The charge on each oil droplet is different. However, it is a simple multiple of 1.609×10^{-19} Coulombs.

(d) The uniform velocity v of spherical particle of radius r falling under the gravity (g) is given by Stoke's law

$$V = \frac{F}{6\pi\eta r} = \frac{4/3\pi r^3 \rho g}{6\pi\eta r} = \frac{2r^2\rho g}{9\eta}$$

where ρ = density and η = Viscocity. It affords and easily measurable quantity, the uniform velocity of the drop on which This experiment is exclusively based, which eliminates mass of the particle (m) from the working formula.

(e) From Milikan's experiment, charge (e) of an electron Comes 1.6091×10^{-19} Coulombs and e/m of a slow speed electron from Thomson's experiment Comes 1.76×10^{11} Coulombs Kg^{-1}. Therefore, the mass (m) of the slow speed electron will be –

$$\frac{e}{e/m} = \frac{1.6091 \times 10^{-19}}{1.76 \times 10^{11}} \text{ Kg}$$

$$\Rightarrow m = 9.1091 \times 10^{-31} \text{ Kg.}$$