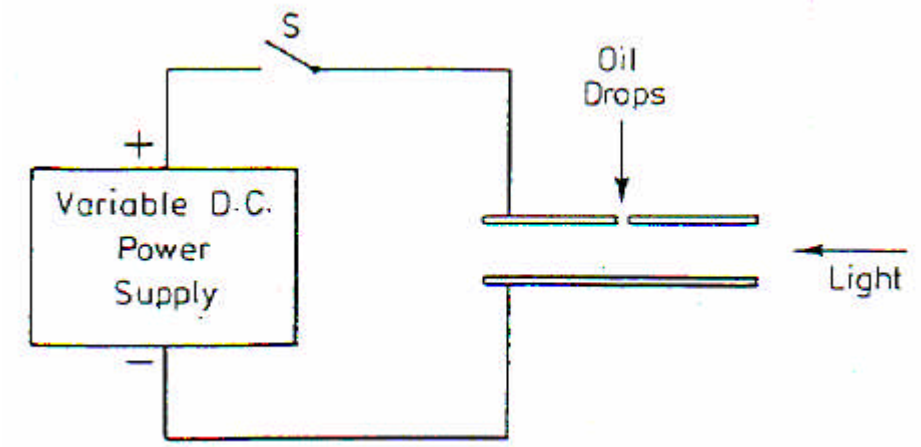
Chapter 16
Short answer question

In the Millikan experiments to measure the charge of an electron, a pair of horizontal parallel

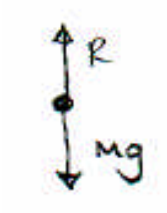


plates is connected to a variable voltage power supply and a switch S (Fig. 1).

Fig. 1

The space between the plates is strongly illuminated. A very few tiny oil drops are allowed to enter this space through a small hole in the upper plate. The drops are viewed with a microscope. They appear as pin-points of light.

(a) With switch S open, an oil drop falls slowly with a steady speed. Draw a labelled diagram showing the drop and the forces acting on it. Explain why it moves with a steady speed.



Drop reaches terminal velocity with air friction (R) equal and opposite to weight (mg).

(b) With switch S closed, it is possible to adjust the output of the power supply so that a drop appears stationary. Explain why the drop is stationary.

Drop is charged so that $qE = mg$ or $q\frac{V}{d} = mg$, since $E = \frac{V}{d}$

(c) If the pin-point of light is watched carefully, it is seen to be 'jiggling' in a random fashion. Explain why this happens.

Random collisions with rapidly moving air particles. (Brownian motion)

(d) When β-particles are allowed to enter the space for a few moments, the drop may suddenly start to move. Explain.

Beta particles knock off electrons on drop and change q. Less electrons more voltage to make E larger

(e) The drop may be brought to rest again by changing the voltage of the power supply. Would you increase or decrease the voltage? Explain.

Since

$$q\frac{V}{d} = mg$$

Then q x V = constant for given d, m, g. For example, if q increases, V decreases and vice versa

The process of admitting β-particles and changing the voltage to balance the drop is carried out several times, each time the potential difference across the plates being measured and the charge on the drop calculated. The results are shown in the table.

p.d. across the plates (volts)	**Charge on drop (10^{-19} coulomb)**
200	3.2
100	6.4
133	4.8
x	12.8

(f) (i) Explain how these results suggest that the electron has a definite charge.

Charge on drop integral multiple of 1.6×10^{-19}C

(ii) What is its probable value?

1.6×10^{-19}C

(iii) What is the missing voltage *x* in the table?

Since $q \times V = \text{constant}$

$12.8 \times 10^{-19} \times x = 640 \times 10^{-19}$

$\therefore x = 50\text{V}$

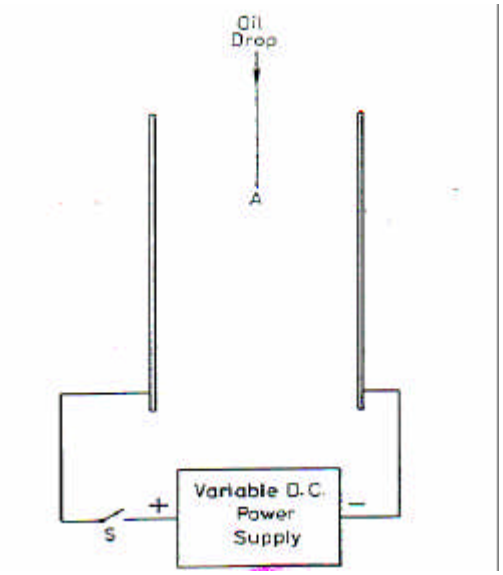
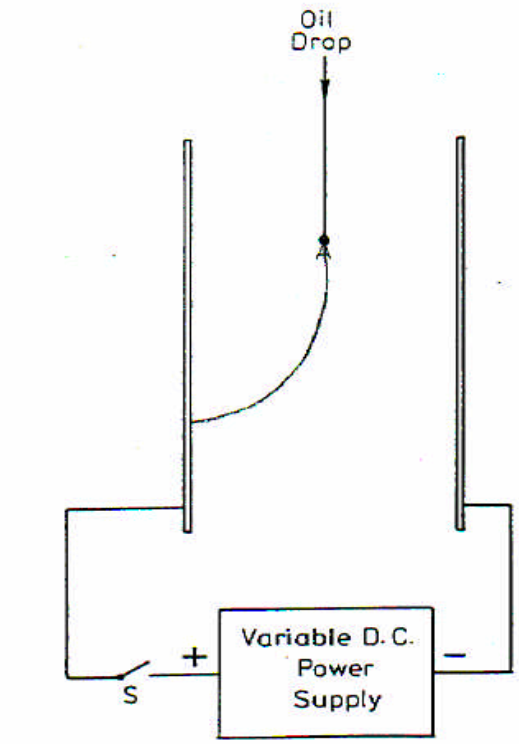


Fig. 2

Imagine the plates now set vertically and the oil drops introduced from above (Fig. 2). With S open, a charged drop falls as far as A and S is then closed.

(g) Copy the plates from Fig. 2 and complete the diagram of the path you would expect the drop to follow. Explain.



Assuming the drop is negative. However, removal of electrons produces a positive charge and the particle will deflect in the opposite direction.