310.

Problem 28.43 (RHK)

In a particular early run (1911), *Millikan observed that the following measured charges, among others, appeared at different times on a single drop:*

6.563×10^{-19} C	13.13×10^{-19} C	19.71×10^{-19} C
8.204×10^{-19} C	16.48×10^{-19} C	22.89×10^{-19} C
11.50×10^{-19} C	18.08×10^{-19} C	26.13×10^{-19} C.

We have to find the value of the quantum of charge e that can be deduced from these data.

Solution:

Let the value of the quantum of charge be e. Therefore, the values of the charges on oil drops measured by Millikan have to be integral multiples of e.

In the ascending order of the values given in the data above we write

$q_1 = n_1 e,$ where $q_1 = 6.563\times10^{-19}$ C and n_1 is some integer.

Similarly, $q_2 = n_2 e$, where $q_2 = 8.204 \times 10^{-19}$ C and n_2 is some integer, and so on.

We work out the ratios

$$\frac{q_2}{q_1} = \frac{8.204 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_2}{n_1} = 1.218,$$

$$\frac{q_3}{q_1} = \frac{11.50 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_3}{n_1} = 1.752,$$

$$\frac{q_4}{q_1} = \frac{13.13 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_4}{n_1} = 2.000,$$

$$\frac{q_5}{q_1} = \frac{16.48 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_5}{n_1} = 2.511,$$

$$\frac{q_6}{q_1} = \frac{18.08 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_6}{n_1} = 2.754,$$

$$\frac{q_7}{q_1} = \frac{19.71 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_7}{n_1} = 3.003,$$

$$\frac{q_8}{q_1} = \frac{22.89 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_8}{n_1} = 3.487,$$

and

$$\frac{q_9}{q_1} = \frac{26.13 \times 10^{-19}\ \text{C}}{6.563 \times 10^{-19}\ \text{C}} = \frac{n_9}{n_1} = 3.981.$$

We now find the smallest integer for which $n_2, n_3, ..., n_9$ will be integers. From the data above, we note that the solution is $n_1 = 4$.

The value of quantum of charge e that can be deduced from the above data of the Millikan's experiment (1911) is

$$e = \frac{6.563 \times 10^{-19}\ \text{C}}{4} = 1.64 \times 10^{-19}\ \text{C}.$$