

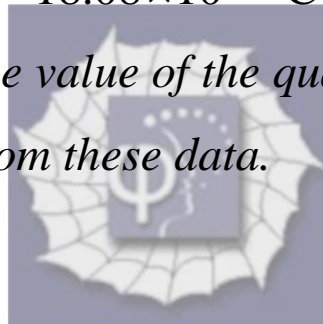
310.

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:

| | | |
|-----------------------------------|-----------------------------------|-------------------------------------|
| $6.563 \times 10^{-19} \text{ C}$ | $13.13 \times 10^{-19} \text{ C}$ | $19.71 \times 10^{-19} \text{ C}$ |
| $8.204 \times 10^{-19} \text{ C}$ | $16.48 \times 10^{-19} \text{ C}$ | $22.89 \times 10^{-19} \text{ C}$ |
| $11.50 \times 10^{-19} \text{ C}$ | $18.08 \times 10^{-19} \text{ C}$ | $26.13 \times 10^{-19} \text{ C}$. |

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 $q_1 = 6.563 \times 10^{-19} \text{ C}$ 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, \dots, 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

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

